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Consumer Protection and Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 mCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^3	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 5, May 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Environmental Control Administration • Bureau of Radiological Health

Reports

Radiological Health Aspects of Spent Radon Seeds

Richard F. Boggs, Gail D. Schmidt, and Kenneth D. Williams[1]

Following three incidents of radiation exposure to individuals wearing jewelry contaminated with radioactivity, the Bureau of Radiological Health (BRH) examined the early development, the present clinical use, and disposal of gold radon seeds, the suspected source of the contamination. The Ad Hoc committee called by the BRH to study the problem recommended that (1) the State and local radiological health agencies that have regulatory authority over radon seeds be familiar with the appropriate regulations, (2) that users of radon be advised to keep an account of radon seeds procured, not to supply unused or spent radon seeds to any unauthorized person and to return all decayed or unwanted radon seeds to the supplier or persons authorized to receive such shipments, (3) gold refiners and processors be alerted to the possibility of receiving contaminated gold and efforts be made to prevent such material from entering the commercial market, (4) the BRH consider the possibility of further investigation of the extent of the problem and consider providing technical assistance through appropriate agencies, and (5) the medical community be encouraged to investigate the feasibility of using other radionuclides for permanent implants.

From April 1967 to September 1968, three incidents in which jewelry contaminated with radioactivity caused overexposure to individuals wearing such jewelry were reported (*1–4*). In each case, it was reported that excessive radiation exposures resulted from wearing gold rings which apparently were fabricated partly or wholly from spent gold radon seeds. Relative to these incidents, the early development and present clinical use of gold radon seeds, methods used in fabricating the seeds, their physical characteristics, and methods for control of spent radon seeds are explained.

Development of radon seeds

Early in the development of radium therapy, it was realized that certain types of tumors could be most effectively treated by inserting the radioactive source directly into the tumor mass. Only bulky radium containers were available for this purpose at first. A technique for utilizing concentrated radon (radium emanation) as the radioactive source was reported by Stevenson in 1914 (*5*). He collected the radon gas in fine, capillary-glass tubes and placed them in hollow-steel needles which were inserted into the tumor and withdrawn at the end of the treatment.

In 1917, Duane (*6*) suggested a procedure for interstitial treatments using glass "radon seeds." The radon gas was collected in a glass tube about 0.4 mm in diameter, divided into sections 3- to 4-mm long, and then implanted directly into the tumor and allowed to remain permanently in situ. The successful practical techniques developed by Dr. H. Janeway at the New York Memorial Hospital, however, often resulted in severe pain due to the intense necrosis produced around each seed by the absorbed beta radiation (*7*).

[1] Messrs. Boggs, Schmidt, and Williams, are members of the Division of Medical Radiation Exposure, Bureau of Radiological Health, Rockville, Md. 20851.

Trends in the use of radon seeds

Radon seeds have been used in the treatment of tumors in 11 different sites in the body. Murphy (*10*) reported in 1959 that five of these sites were frequently treated with radon, four sites only occasionally, and two of the sites were no longer being treated with radon.

The most effective application of radon seeds in radiotherapy is for bladder cancer. The seeds are also useful for small localized superficial lesions of the floor of the mouth, small tonsillar lesions, small lesions of the urethra located at the external orifice, and for pituitary gland irradiation.

In a recent survey of the use of radionuclides in medicine, supported by the Bureau of Radiological Health (BRH), 158 physicians reported using radon seeds in the treatment of 2,241 patients during 1966 (*11*). These physicians also reported a total of 3,069 administrations of radon seeds which represents 6.2 percent of the administrations in all brachytherapy procedures. From this survey data, it is projected that nationally, 231 physicians administered 4,500 radon implants in 3,300 patients in the United States during 1966.[2]

[2] U.S. Department of Health, Education, and Welfare, National Center for Radiological Health followup study to "Survey of the Use of Radionuclides in Medicine" (unpublished data).

The radon needles used by Regaud in his early 1920 studies had a wall thickness of 0.5 mm of platinum, sufficient to filter out nearly all beta particles (*8*), thereby providing evidence that tumors could be efficiently treated with radon without painful necrosis. This helped to establish that the therapeutic benefit was derived only from the gamma radiation.

Gold tubing with a wall thickness of 0.3 mm was used by Failla in the making of filtered radon seeds (*9*) and proved to be the preferred encapsulation. This thickness of gold filtered out over 99 percent of the beta radiation; the seeds were sufficiently small and could be permanently implanted under local anesthesia. Gold radon seeds received immediate acceptance by radiotherapists and are commercially available today in basically the same form as those produced by Failla.

Physical characteristics of radon seeds

The physical characteristics of gold radon seeds (figure 1) used for permanent implants are as follows:

length—4.0 mm
external diameter—0.75 mm
wall thickness—0.30 mm
wall material—24K gold
total gold weight—0.0327 g
radioactivity—0.05 to 5 mCi at the time of use.

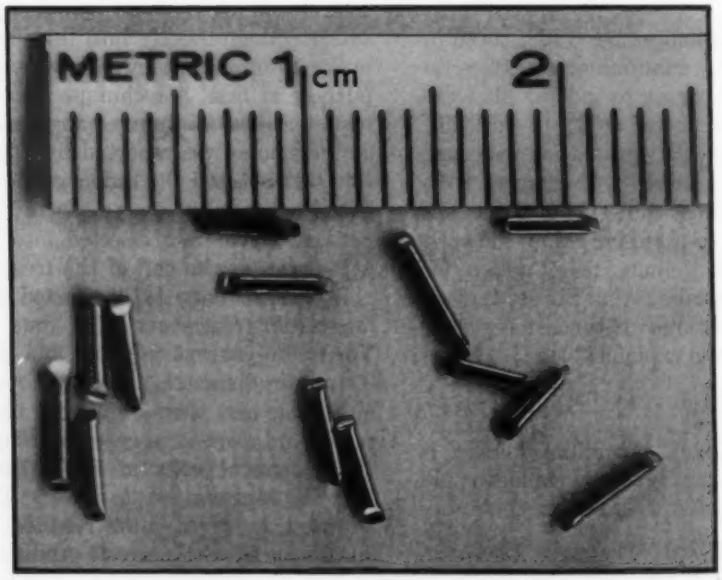

Figure 1. Radon filled gold seeds

Gold–198 and iridium–192 seeds have been used as substitutes for radon in permanent implant therapy. In 1966, as indicated by the above survey, these substitutes for radon accounted for approximately 18 percent of the reported permanent implant administrations. Currently, three other radionuclides, xenon–133, cesium–131, and iodine–125, are being investigated for this purpose (*12–13*). All of these radionuclides have the advantage of low-photon emission energies, which reduces protective shielding requirements; however, differences in half-life have raised the question of biological equivalents to radon and many physicians have been reluctant to change. The Conference on Medical Uses of Radium and Radium Substitutes has recommended that gold–198 be used as a substitute for radon seeds (*14*). This recommendation has been supported by a panel convened by the International Atomic Energy Agency (*15*). As more clinical experience is accumulated it is anticipated that the use of radon will decline.

Radioactivity from radon seeds

Since radon has a half-life of 3.8 days (table 1), approximately 2 months later essentially all of the radon (Rn) atoms will have decayed through the short-lived daughters to lead–210. The radioactivity of the lead–210 at that time is equal to 0.0005 of the initial radon activity.

Therefore, for an initial filling of 1 mCi of radon–222, the lead–210 ingrowth activity will be 0.0005 millicuries or 0.5 microcuries. One mCi (radon) is a commonly used activity for radon seeds at the time of implantation. Since these sources are delivered commercially via air and rail transportation, and since radon has a half-life of 3.8 days, the initial filling activity will be greater and may be two to four times higher than the activity at the time of implantation. The activity of lead–210 in the decayed or spent radon seed would correspond to the activity at the time of initial filling rather than at time of implantation.

The radiation produced by the long-lived daughters, radium D, E, and F, are given in table 1. In a spent radon seed, all of the alpha

Table 1. Physical characteristics of radium–226, radon–222 and radon daughters[a,b]

Characteristics	Nuclide	Historical name	Half-life	Principal radiation (MeV) (percent occurrence)
An alkaline earth metal and bone-seeker (as are calcium, strontium, and barium)	Radium–226	Radium	1,622 yr	α 4.78(94), 4.59(6) γ 0.19(4)
A member of the family of inert gases	Radon–222	Radon (sic)	3.82 days	α 5.48(100)
	Polonium–218	Radium A	3.05 min	α 6.00(100)
Short-lived daughters effective half-life of 30 min. (essentially complete decay in 4 hours)	Lead–214	Radium B	26.8 min	β principal 0.46(50), 0.66(40) γ principal 0.24(11), 0.29(24), 0.35(44)
	Bismuth–214	Radium C	19.7 min	β various 0.74(20) to 3.18(15) γ various 0.61(45) to 2.43(2)
	Polonium–214	Radium C'	1.6×10^{-4} sec	α 7.68 (100)
Long-lived daughters about 20 yr. half-life alpha and beta-particle emitters with weak gamma rays	Lead–210	Radium D	19.4 yr	β 0.06(17), 0.02(83) γ 0.05(4)
	Bismuth–210	Radium E	5.0 days	β 1.16(100)
	Polonium–210	Radium F	138.4 days	α 5.30(100)
Stable lead	Lead–206	Radium G	Stable	

[a] The gamma radiation from medical radium and radon sources is primarily due to the short-lived daughters of radon.
[b] Excerpted from reference (*16*).

particles and over 99 percent of the beta particles are absorbed by the 0.3 mm gold wall. The 47 keV gamma rays from lead–210 are almost entirely eliminated by the gold wall. Johns and Skarsgard state that the slowing down of the beta particles in the gold produces bremsstrahlung with a spectral energy of 50 to 500 keV (*17*). Theoretical calculations of the bremsstrahlung intensity by Johns and Skarsgard gave an exposure rate of 41.7 μR/hr at 1 cm from a 1 mCi (radon) seed. Not considered inconsistent with the theoretical value is their experimental measurement of five seeds using a NaI (T1) crystal with a multichannel analyzer yielding an exposure rate of 76.5 μR/hr.

The spectrum of the spent radon seeds obtained by Johns and Skarsgard is shown in figure 2. The bremsstrahlung spectrum without filtration is at a maximum at zero energy and falls continuously to zero as the photon energy is increased to 1.16 MeV. The low energy end of this continuous spectrum is strongly filtered by the gold. The peak of 70 keV results from the K-shell x rays of gold which are produced by many of the photons above the K edge of gold (80.8 keV) and which are less fully absorbed for two reasons; (1) the reduced absorption coefficient below the K edge and (2) the fact that they are produced throughout the thickness of the wall and hence incur lower average transmission loss. Also, the 47 keV gamma ray of lead–210 has been sufficiently attenuated so that it is lost in the bremsstrahlung spectrum.

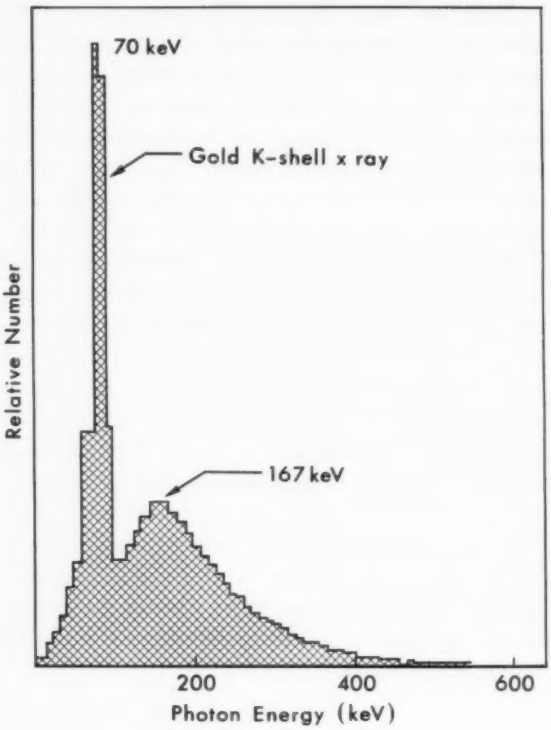

Figure 2. Spectrum for radon seeds

External radiation from beta sources

The dose rate near a plane source of beta particles of maximum energy in the region of 0.5 to 3.0 MeV is about 7 rad/hr per μCi/cm^2 as estimated by Chamberlain (*18*); this figure would be increased by a factor of perhaps 1.5 by backscattering of electrons from the surface carrying the source (*18*). According to Loevinger, the calculated dose rate for an infinite thin plane beta source is about 6 rad/hr per μCi/cm^2 at a distance of 0.1 mm from the surface of the source (*19*). This assumes that all of the lead–210 radioactivity is deposited on the surface of the source. Assuming that the lead–210 radioactivity is uniformly dispersed in an infinite gold slab with a thickness greater than 0.23 mm (which may be considered infinite thickness), the calculated dose rate at the surface of the source is about 0.34 rad/hr per μCi/g at the surface of the source (*20*).

It has been previously shown that 1 millicurie of radon will yield about 0.5 microcuries of lead–210. This activity, when uniformly dispersed in a gold seed, yields a specific activity of 15.3 μCi/g. Based on these data, the surface dose rate from a gold slab 0.23 mm thick is:

$$R_\beta\,(0,\ \infty) = 0.34 \times 15.3 = 5.2 \text{ rad/hr}$$

Gold rings (wedding bands) usually have dimensions that approximate an infinite slab (with a thickness greater than 0.23 mm) for exposure points that are in contact with the ring. Harley measured beta radiation doses of up to 900 mR/hr which, though lower, appear consistent with this calculation (*2*). One would expect some dilution of the lead–210 by the metal alloyed with the gold, since gold jewelry is generally not more than 14 karat, while gold seeds are 24-karat gold. Contaminated gold may be further diluted in radioactivity by being mixed with uncontaminated

gold. Approximately 100 to 200 gold seeds would be required to make a single gold wedding band.[3]

Control of spent radon seeds

The disposal of spent radon seeds is controlled by the regulations of the Agreement States and other States which have enacted similar regulations for the control of naturally occurring radionuclides. The Agreement States are authorized by the U.S. Atomic Energy Commission to assume control over certain radionuclides previously under the jurisdiction of the AEC. There are currently 19 Agreement States and 15 additional States which are considered to have comprehensive radiation control regulations (*21*) that are similar to the "Suggested State Regulations for Control of Radiation" of the Council of State Governments (*22*). These regulations provide that no licensee shall dispose of any radioactive material except by special procedures which include ground burial and release to the sewerage system, and special authorization.

The Bureau of Radiological Health has been able to document the existence of only 18 radon plants in the United States, however, it is believed that 30 to 40 plants operated during past years. Today, there are only three known operating plants: Memorial Hospital for Cancer and Allied Diseases, New York, N.Y.; the Radium Chemical Company, Inc., New York, N.Y.; and Radium Service Corporation of America in Kenilworth, Ill. New York State is one of the Agreement States, and therefore two of these facilities come under the same comprehensive regulations for control of the disposal of radioactive material as noted for the radon seed user. The disposal of spent radon seeds by Radium Service Corporation of America is governed by the regulations of the Illinois Department of Public Health which are similar to those of an Agreement State.

The Gold Filled Manufacturers Association has indicated that the largest refiner of gold has for some time made radioactivity checks on their gold and has never detected any radioactivity. Because of the monetary value of gold, there are government controls which require records of its sale and purchase. While most of the gold in this country is refined by several large companies, there are hundreds of small local concerns that may refine or process gold, making it difficult to provide radioactivity measurements of all scrap gold entering the market.

Conclusions

While it is known that in the past, gold radon seeds were collected and sold to gold manufacturers, no clear evidence has been obtained to prove that such seeds have resulted in the reported incidents. At the present time, all spent radon seeds at the three operating radon plants are retained in storage at the facilities.

On January 7, 1969, the Bureau of Radiological Health called a meeting of an Ad Hoc Committee on the Control of Spent Radon Seeds[4] to review the problem in depth and to make recommendations on any future actions which should be taken. The conclusion of this committee is that based upon the available evidence, the radioactive contamination of gold from spent radon seeds does not appear to be a wide-spread public health hazard. However, a few cases of skin reaction that could have resulted in significant biological damage have been observed as a result of gold contaminated in previous years. Therefore, the committee recommended the following:

1. Although radon seeds lose their medical usefulness in a short time, the long-lived daughter products continue to constitute a potential radiation hazard if uncontrolled. State and local radiological health agencies which have regulatory authority over radon seeds should insure that purchasers and users of radon seeds are familiar with the appropriate regulations.

[3] A single gold seed is worth about 3 cents based upon a gold price of $35.00 per troy ounce.

[4] The members of the committee are Dr. John S. Laughlin (chairman), radiation physicist, Memorial Hospital, New York City; Mr. Thomas Cashman, director, Bureau of Radiological Health, New York State Department of Health, Albany; Mr. Russell F. Cowing, radiological physicist, New England Deaconess Hospital, Cancer Research Institute, Boston; Dr. Warren M. Holm, vice president, Radium Chemical Company, New York City; Dr. John Harley, director, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York City; and Dr. Norman Simon, radiologist, New York City.

2. Although the Council of State Governments "Suggested State Regulations for Control of Radiation" (*22*) specifies the procedures for proper handling and disposal of all radioactive materials, it is recommended that the users of radon be advised, (a) to keep an account of radon seeds procured, (b) not to supply unused or spent radon seeds to any unauthorized person, and (c) to return all decayed or unwanted radon seeds to the supplier or persons authorized to receive such shipments.

3. Gold refiners and processors should be alerted to the possibility of receiving contaminated gold, and efforts should be made to prevent such material from entering the commercial market.

4. The Bureau of Radiological Health should consider the possibility of further investigation of the extent of the problem and consider providing technical assistance, including methodology of detection, through appropriate agencies.

5. The medical community, including agencies supporting research designed to reduce radiation exposure, should be encouraged to investigate the feasibility of using other radionuclides for permanent implants. It is recognized that radon–222 is still an important therapeutic modality and every effort should be made to encourage its proper use.

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Technical Notes

Survey of Veterinary X-Ray Units in Alabama

William T. Willis and J. Edward Cowan[1]

The Bureau of Environmental Health of the Alabama State Department of Public Health has completed a radiological health survey of 65 x-ray units and a fluoroscope used in the practice of veterinary medicine. This report discusses the survey registration procedure and results, the regulatory requirements for veterinary radiographic units, the compliance status for each requirement, and the compliance status for the total number of veterinary facilities and x-ray units at the time of the survey, and the completion of the survey. By agreement, the 24 veterinary units located in Jefferson County (Birmingham) were inspected independently and brought into compliance with the Alabama regulations for control of radiation; these units are excluded from this report.

The purpose of the survey was to determine the nature and extent of radiological health hazards occurring during the operation of veterinary x-ray units, and to reduce the hazards to the lowest practical level. The survey was successful in achieving the following objectives:

1. determining the number and location of all veterinary x-ray units;
2. performing a physical inspection of each x-ray unit;
3. determining the compliance status of each unit; and
4. bringing units into full compliance with Alabama regulations (*1*).

[1] Mr. Willis is director, and Mr. Cowan was assistant director, Division of Radiological Health, Bureau of Environmental Health, Alabama Department of Public Health, Montgomery, Ala. Mr. Cowan is presently chief, State Program Services Section, Compliance and Control Program, Bureau of Radiological Health, Rockville, Md. 20851.

The regulations governing medical, dental, and veterinary x-ray units were adopted in 1965 by the Alabama State Board of Health. The specific regulatory requirements for Alabama veterinary units are identical to the suggested regulations of the Council of State Governments which were prepared in cooperation with the U.S. Atomic Energy Commission and the U.S. Public Health Service (*2*).

In initiating the survey, the State Health Officer advised each veterinarian who had registered an x-ray unit that the unit would be inspected. The initial inspection and follow-up compliance visits were conducted over a period of 6 months by a team of 2 registered x-ray technicians.

Registration

Prior to inspection of the x-ray units, a postcard registration form was sent to the 193 veterinarians listed in the "Directory of Licensed Veterinarians in Alabama." As indicated in table 1, a number of veterinarians were reluctant to respond to the registration request. After three registration requests, a combined total of 149 registration cards were returned leaving a remainder of 44 veterinarians who did not respond. Of the 149 registration cards returned, 67 veterinarians indicated possession of an x-ray unit. To complete the registration, the 44 veterinarians who did not return a card were contacted by telephone and it was learned that 22 owned x-ray units. Final registration results showed that 65 operable veterinary x-ray units and one hand-held fluoroscope were located at a total of 60 facilities.

The number of registered x-ray units per county, in those counties with units, ranged from 1 to 13.

Table 1. Veterinarians response to registration requests

Number of registration requests	Requests mailed	Number of respondents
193	December 1966	72
124	February 1967	58
70	March 1967	19
387		149

The majority of units were concentrated in a few counties; 44 (or two-thirds of the total) were located in only 8 counties. Table 2 shows the number of counties with specified numbers of x-ray units.

Table 2. Counties with specified number of x-ray units

Number of counties	Number of units in county	Total units
16	1	16
3	2	6
2	3	6
1	4	4
3	5	15
1	6	6
1	13	13
27		66

Equipment requirements and results

The discussion of regulatory requirements and survey results is categorized into the areas of equipment, operating procedures, shielding, and personnel monitoring. Each individual regulatory item inspected is listed in table 3.

Filtration reduces undesirable densities in a radiograph through the absorption of lower energy x rays and results in improved radiographic quality. The use of filtration also results in less radiation exposure to the operator and to persons holding the animal. Measurements taken during the survey showed a significant radiation exposure reduction directly related to the use of filtration. In a typical measurement, the addition of 2 millimeters aluminum filtration reduced the output of the primary beam from 800 to 400 milliroentgens per second at 36 inches, using 10 milliamperes and 60 kilovolts. Scattered radiation showed a corresponding reduction of over 40 percent.

The survey determined that more veterinary x-ray units were in noncompliance with the item of filtration than any other requirement. The exact thickness of filtration required is dependent upon the operating kilovolts, but the majority of units should be provided with a minimum of 2 millimeters aluminum-equivalent filtration.

Table 3. Compliance of veterinary x-ray units by regulatory item (before and after survey)

Regulatory item	In compliance at time of initial inspection		In compliance after followup inspections	
	Number	Percent	Number	Percent
Equipment:				
Filtration	32	49	65	100
Collimation	62	95	65	100
Timer	64	98	65	100
Tube housing	65	100	65	100
Operating procedures:				
Operator stands 6 feet away, or behind barrier or wears leaded apron	65	100	65	100
Wears leaded apron and gloves when holding animals	55	85	64	98
Shielding	65	100	65	100
Personnel monitoring	64	98	64	98

Fifty-one percent of the total x-ray units inspected were equipped with less than the required thickness of aluminum-equivalent filtration. Of greater significance is the fact that 28 of 33 deficient units were without any filtration other than the one-half millimeter inherent. Five units had 1 millimeter of filtration each.

As an additional service to the veterinarians, filters were inserted in all x-ray units that were equipped with less than the required thickness of aluminum. All units were brought into compliance by positioning the required 1 or 2 millimeters of aluminum in the port to intercept the primary beam. Thus, the item found most frequently in noncompliance was corrected without difficulty and at minimal cost.

As in medical and dental radiography correct collimation is important in veterinary radiography, but its use is not based on genetic considerations of the animal being radiographed. Collimation is necessary in veterinary radiography to direct the primary beam to the area of clinical interest and to reduce the radiation exposure to the holder of the animal.

The adequacy of collimation was determined for the majority of units by the use of fluorescent strips. In this procedure the size of the beam was observed when the strips fluoresced as the tube was energized. In those instances where the x-ray room could not be darkened sufficiently to observe the fluorescent strips, the beam size was determined by measurement and calculation using similar triangles and the formula, $a/b = A/B$. In these cases, the diameter of the beam (B) at any distance from the tube (A) for any given cone was determined by measuring the

distance from the tube target to the end of the cone (a), the diameter of the cone (b), and solving for B by using the equation, $B = \frac{Ab}{a}$.

Sixty-two of 65 units were equipped with collimators that restricted the primary beam to the area of clinical interest. Three units were not equipped with any type collimator.

Timers for veterinary x-ray units were found to be in full compliance. All units were equipped with timing devices that terminated the exposure after a preset time, as required. Sixty-four of 65 units were in compliance with the requirement for an exposure device. The one unit in noncompliance could be operated without continuous pressure on the exposure device by the operator.

The x-ray tube housing for each of the 65 units was measured for leakage. Radiation measurements taken with the port blocked showed that all units were well below the maximum allowable tube-housing leakage of 100 milliroentgens in 1 hour at 1 meter.

Procedural requirements and results

Operator protection is one of the more important procedural requirements. Operators of veterinary x-ray units may use three different methods for radiation protection. The operator may stand a minimum of 6 feet from the animal being radiographed, behind a protective barrier, or may wear a leaded apron.

The survey determined that the requirement of operator protection was in compliance at every x-ray facility. The operators of 61 units stood 6 feet from the animal. In addition, the operators of 20 of the 61 units also stood behind a barrier and the operators of 15 of the 61 units wore a leaded apron.

The animal being radiographed is generally immobilized. The usual procedure is to anesthetize the animal, then hold it in the desired position. The regulations permit the holding of animals, but a person may not be employed to perform this service regularly. Additionally, the person holding the animal must be provided with a leaded apron and gloves.

The survey showed that none of the 60 facilities regularly employed an individual to hold animals. However, 10 facilities did use individuals, usually the owner, to hold the animal without providing the person with the required protective leaded apron and gloves. This item was found to be the second most frequently occurring item of noncompliance and is perhaps the most significant because of the resultant radiation exposure. The increased significance of this item arises from the fact that the person holding the animal is standing on the immediate perimeter of the primary beam and will receive unnecessary radiation exposure unless protective apron and gloves are provided. For an x-ray unit operating at 65 kVp and 15 milliamperes, one measurement showed that an individual holding an animal without a protective apron and gloves would be exposed at the rate of 3 milliroentgens per second to the hands and 1.5 milliroentgens per second to the whole body. Leaded apron and gloves would reduce this unnecessary exposure to practically zero.

Shielding requirements and results

Shielding for a veterinary radiographic facility must be of sufficient thickness to reduce radiation levels in unrestricted areas so that an individual's exposure for continuous occupancy may not exceed 2 milliroentgens in any 1 hour, 100 milliroentgens in 7 consecutive days, and 500 milliroentgens in any 1 year. The adequacy of barrier thickness was determined by actually measuring radiation levels at nonrestricted locations. For every facility the calculations showed that the existing barrier thickness was sufficient to meet the standard. The exceedingly low workloads were a major factor in shielding adequacy. Table 4 illustrates the workloads.

Forty percent of the veterinary units are used to take 1 exposure per week, 67 percent are used

Table 4. Workloads of 65 veterinary x-ray units

Exposures per week	Number of units	Total units (percent)	Total exposure per week
0	3	5	[a] <1
1	23	35	24
2	8	13	16
3	9	14	27
4	1	1	4
5	4	6	20
6	4	6	24
7	0	0	0
8	3	5	24
9	0	0	0
10	2	3	20
15	3	5	45
20	2	3	40
30	2	3	60
60	1	1	60
Total	65	100	364

[a] Considered as zero in total exposures per week.

to take 3 or less exposures per week, and the entire 65 units are used to make only 364 exposures per week. The workload for the combined total of 65 units is 68 milliampere-minutes per week. The low level of tube on-time is a major factor in lessening the public health significance of veterinary x rays relative to other medical and industrial uses of x-ray equipment.

Personnel monitoring requirements and results

The regulations specify that personnel monitoring must be provided for all persons who operate a mobile x-ray unit and for each individual who receives or is likely to receive a dose in excess of 25 percent of 1.25 roentgens per calendar quarter. Operator exposure is related to on-time of an x-ray unit, thus the workload becomes an important consideration in estimating whether or not an x-ray operator should wear a film badge to record radiation exposure. The x-ray operators at two educational institutions were provided with film badges. Fifty-seven of 59 private practice facilities do not provide the operators with film badges, and are not required to do so by the regulations. Therefore, only 1 of 60 facilities was determined to be in noncompliance with the requirement of personnel monitoring. The one facility in noncompliance possessed a mobile x-ray unit which requires personnel monitoring regardless of workload or level of operator exposure. The entire 65 units required 85 operators, an average of only 1.3 operators per x-ray unit.

Compliance with the requirement of personnel monitoring occurred because the low tube on-time and existing operator protection equipment and method kept radiation exposure at all private practice facilities well below 25 percent of the personnel exposure standard. Actual radiation measurements for every facility made at the various operator positions under normal operating procedures, and subsequent personnel exposure calculations, provided documentation that 59 of 60 facilities were in full compliance with the personnel monitoring requirement, although 87 percent of all operators did not wear a film badge.

Compliance

The term "compliance" as used in this report means that each x-ray unit meets every requirement for veterinary x-ray units as specified in Alabama regulations for the control of radiation. The compliance status index will be used to evaluate the results of this survey, that is, a comparison of the number of x-ray units in compliance at the time of the initial inspection with the number of units in compliance after the completion of all follow-up inspections. Although this method for evaluating the accomplishments of the survey does not quantify the dose reduction, it carries a presumption that unnecessary radiation is eliminated when units are brought into compliance.

The veterinarian's compliance with the regulatory requirements was excellent. At the time of the initial inspection only 26 units were in compliance. Correction of the single requirement of filtration by the survey team increased the number of units in compliance from 26 to 50, and after completion of the follow-up inspections, 64 of 65 radiographic veterinary x-ray units were in compliance with every regulatory requirement. Table 3 presents this data in tabular form. The owner disposed of the hand-held fluoroscope as its use was specifically prohibited by the regulations.

Summary

All known veterinary x-ray units in Alabama have been registered and inspected. Sixty-five radiographic units and one fluoroscope were physically inspected for compliance with all applicable provisions of Alabama regulations for control of radiation.

At the time of the initial inspection, only 26 of 65 units were found to be in compliance. After completion of the initial inspection and all follow-up visits, 64 of 65 x-ray units were in compliance with the regulations. Disposal was made of the hand-held fluoroscope.

The item of filtration was found to be in noncompliance more frequently than any other requirement. Filtration was corrected at the time of the inspection by the survey team, thus the number of units in compliance was increased during the inspection from 26 to 50. The second most frequently occurring item of noncompliance and perhaps the item of greatest importance, was the holding of animals without wearing protective leaded apron and gloves.

Shielding was determined to be sufficient for all facilities. As radiation exposure is a direct func-

tion of tube on-time, the exceedingly low workloads contributed to the shielding adequacy.

Only one facility was found to be in noncompliance with the requirement of personnel monitoring, although x-ray operators at the majority of facilities did not wear film badges. The low workloads minimized radiation exposure and was a factor in negating the need for film badges.

Unnecessary radiation exposure during the operation of veterinary x-ray units has been reduced as a result of the survey. However, the 65 x-ray units and the 85 operators are small in number when compared to other medical uses of x-ray equipment. This fact, joined with the low level of tube on-time and existing protective equipment, reduces the public health significance of veterinary x-rays and suggests a low priority for future reinspections.

REFERENCES

(*1*) Alabama Regulations for the Control of Radiation, 1966.

(*2*) Council of State Governments Suggested State Regulations for Control of Radiation; Part E, Use of X-ray in the Healing Arts (1964).

SECTION I. MILK AND FOOD

Milk Surveillance, January 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium–90, iodine–131 and cesium–137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milk-

shed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviation
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine–131, Cesium–137, Barium–140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine–131, cesium–137, and barium–140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reportining level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8*, *9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)	Range II (pCi/day)	Range III (pCi/day)
Strontium-89	Bone	1.5	0.5	[b] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[b] 200	0–20	20–200	200–2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[c]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] For strontium-89, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[c] The guides expressed here were not given in the FRC reports, but were calculated using appropropriate FRC recommendations.

radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent milk concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

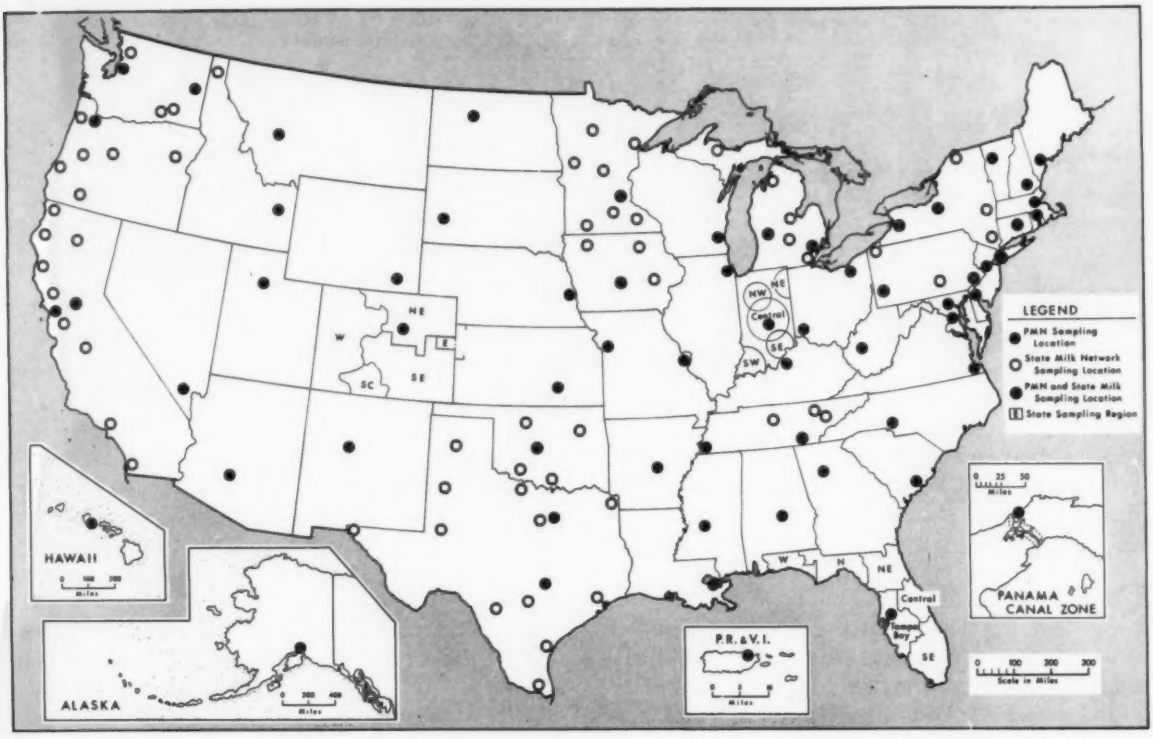

Figure 2. State and PMN milk sampling locations in the United States

estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131 and cesium–137 for January 1969 and the 12-month period, February 1968 to January 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium–89 and barium–

Table 3. Concentration of radionuclides in milk for January 1969 and 12-month period, February 1968 through January 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	6	8	0(3)	0	9(3)	14
Alaska:	Palmer[c]	P	7	5	0(4)	0	8(4)	12
Ariz:	Phoenix[c]	P	0	1	0(5)	0	0(5)	2
Ark:	Little Rock[c]	P	16	21	0(4)	0	16(4)	19
Calif:	Sacramento[c]	P	0	2	0(5)	0	0(5)	4
	San Francisco[c]	P	0	1	0(5)	0	0(5)	4
	Del Norte	P	9	18	0	0	11	19
	Fresno	P	0	0	0	0	0	4
	Humboldt	P	4	4	0	0	0	11
	Los Angeles	P	0	1	0	0	0	6
	Mendocino	P	0	2	0	0	0	4
	Sacramento	P	0	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	3	4	0	0	0	4
	Sonoma	P	0	1	0	0	0	4
Colo:	Denver[c]	P	6	5	0(5)	0	0(5)	5
	West	R	(d)		(c)	(c)	(c)	(c)
	Northeast	R	(d)		NS	(c)	NS	(c)
	East	R	(d)		NS	(c)	NS	(c)
	Southeast	R	(d)		NS	(c)	NS	(c)
	South Central	R	(d)		NS	(c)	NS	(c)
Conn:	Hartford[c]	P	8	9	0(5)	0	12(5)	12
	Central	R	NS		NS		NS	
Del:	Wilmington[c]	P	9	10	0(5)	0	4(5)	8
D.C.:	Washington[c]	P	7	9	0(5)	0	2(5)	7
Fla:	Tampa[c]	P	9	8	0(4)	0	57(4)	66
	West	R	6	13	0	3	20	22
	North	R	8	15	0	0	25	27
	Northeast	R	7	8	0	2	72	81
	Central	R	8	9	0	2	47	80
	Tampa Bay area	R	7	8	0	0	63	72
	Southeast	R	7	9	0	0	105	111
Ga:	Atlanta[c]	P	12	14	0(4)	0	19(4)	20
Hawaii:	Honolulu[c]	P	2	4	0(4)	0	0(4)	3
Idaho:	Idaho Falls[c]	P	5	6	0(4)	0	7(4)	9
Ill:	Chicago[c]	P	8	9	0(4)	0	15(4)	11
Ind:	Indianapolis[c]	P	NA	8	0(4)	0	7(4)	6
	Northeast	P	10	11	0	0	0	11
	Southeast	P	8	11	0	0	20	13
	Central	P	7	9	0	0	13	10
	Southwest	P	9	9	0	0	0	12
	Northwest	P	7	10	0	0	17	13
Iowa:	Des Moines[c]	P	3	7	0(5)	0	1(5)	5
	Iowa City	P	6(2)	7	0	0	14	6
	Des Moines	P	4(4)	7	0	0	12	4
	Spencer	P	4(6)	6	0	0	0	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	8	0(4)	0	3(4)	4
Ky:	Louisville[c]	P	10	12	0(4)	0	11(4)	7
La:	New Orleans[c]	P	19	20	0(3)	0	16(3)	23
Maine:	Portland[c]	P	11	12	2(4)	1	23(4)	28
Md:	Baltimore[c]	P	8	10	0(4)	0	7(4)	8
Mass:	Boston[c]	P	10	12	0(4)	0	18(4)	24
Mich:	Detroit[c]	P	9	9	0(4)	0	10(4)	11
	Grand Rapids[c]	P	10	11	0(4)	0	14(4)	15
	Bay City	P	NA	4	NA	(c)	NA	7
	Charlevoix	P	NA	5	(c)(3)	(c)	10	9
	Detroit	P	NA	4	(c)(4)	(c)	3	5
	Grand Rapids	P	NA	5	(c)(4)	(c)	6	8
	Lansing	P	NA	4	(c)(2)	(c)	5	3
	Marquette	P	NA	7	(c)(3)	(c)	30	26
	Monroe	P	NA	3	(c)(2)	(c)	0	1
	South Haven	P	NA	0	(c)(2)	(c)	0	0
Minn:	Minneapolis[c]	P	12	11	0(4)	0	11(4)	13
	Bemidji	P	18	16	0	0	23	24
	Mankato	P	NA	6	0	0	0	0
	Rochester	P	4	9	0	0	13	0
	Duluth	P	21	22	0	0	35	32
	Worthington	P	7	6	0	0	36	0
	Minneapolis	P	14	12	0	0	15	14
	Fergus Falls	P	8	10	0	0	30	10
	Little Falls	P	10	10	0	0	42	17
Miss:	Jackson[c]	P	12	17	0(4)	0	20(4)	16
Mo:	Kansas City[c]	P	6	8	0(5)	0	2(5)	5
	St. Louis[c]	P	8	9	0(4)	0	0(4)	6
Mont:	Helena[c]	P	5	4	0(4)	0	2(4)	8
Nebr:	Omaha[c]	P	6	7	0(5)	0	0(5)	5
Nev:	Las Vegas[c]	P	3	1	0(4)	0	2(4)	3
N.H.:	Manchester[c]	P	10	13	0(4)	0	22(4)	34
N.J.:	Trenton[c]	P	9	10	0(5)	0	8(5)	11

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for January 1969 and 12-month period, February 1968 through January 1969—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued							
N.Mex: Albuquerque[c]	P	4	3	0(4)	0	3(4)	2
N.Y.: Buffalo[c]	P	7	8	0(5)	0	7(5)	10
New York City[c]	P	NA	12	0(4)	0	15(4)	16
Syracuse[c]	P	7	9	0(4)	0	5(4)	8
Albany	P	11(5)	9	0	0	(e)(5)	(e)
Buffalo	P	NA	7	NA	0	NA	(e)
Massena	P	10(3)	11	0(3)	0	22(3)	22
Newburg	P	15(5)	11	0(5)	0	(e)(5)	(e)
New York City	P	14(4)	12	0(4)	0	(e)(3)	(e)
Syracuse	P	11(2)	7	0(3)	0	(e)(3)	(e)
N.C.: Charlotte[c]	P	14	15	0(4)	0	9(4)	11
N.Dak: Minot[c]	P	10	11	0(6)	0	14(6)	14
Ohio: Cincinnati[c]	P	9	9	0(4)	0	7(4)	6
Cleveland[c]	P	8	9	0(5)	0	9(5)	8
Okla: Oklahoma City[c]	P	11	10	0(4)	0	3(4)	6
Oklahoma City	P	(d)		NA		NA	
Enid	P	(d)		NA		NA	
Tulsa	P	(d)		NA		NA	
Lawton	P	(d)		NA		NA	
Ardmore	P	(d)		NA		NA	
Ore: Portland[c]	P	4	8	0(8)	0	10(8)	15
Baker	P	0	3	(e)	(e)	24	5
Coos Bay	P	3	10	(e)	(e)	25	15
Eugene	P	5	4	(e)	(e)	(e)	15
Medford	P	0	2	(e)	(e)	43	13
Portland composite	P	2	5	(e)	(e)	(e)(3)	8
Portland local	P	3	5	(e)	(e)	17(3)	9
Redmond	R	0	2	(e)	(e)	18	8
Tillamook	R	5	8	(e)	(e)	24	27
Pa: Philadelphia[c]	P	9	10	0	0	6	8
Pittsburgh[c]	P	11	12	0	0	10	12
Dauphin	P	0	7	0	0	19	17
Erie	P	8	13	0	0	17(2)	22
Philadelphia	P	5	10	0(5)	0	13(5)	17
Pittsburgh	P	7	12	0(4)	0	18(4)	16
R.I.: Providence[c]	P	8	10	0(5)	0	16(5)	19
S.C.: Charleston[c]	P	12	14	0(4)	0	17(4)	25
S.Dak: Rapid City[c]	P	10	9	0(5)	0	2(5)	10
Tenn: Chattanooga[c]	P	12	13	0(4)	0	11(4)	13
Memphis[c]	P	9	11	0(5)	0	4(5)	6
Chattanooga	P	11	12	3(4)	0	10(4)	7
Clinton	P	14	13	0(2)	0	12(2)	19
Knoxville	P	12	11	0(2)	0	9(2)	15
Nashville	P	13	9	0(2)	0	15(2)	11
Tex: Austin[c]	P	0	3	0(4)	0	5(4)	3
Dallas[c]	P	5	8	0(4)	0	11(4)	7
Amarillo	R	NA	4	NA	0	NA	0
Corpus Christi	R	NA	4	NA	0	NA	3
El Paso	R	NA	2	NA	0	NA	0
Fort Worth	R	2	6	0	0	0	8
Harlingen	R	NA	4	NA	0	NA	0
Houston	R	6	10	0	0	20	19
Lubbock	R	NA	4	NA	0	0	2
Midland	R	2	3	0	0	0	0
San Antonio	R	NA	3	NA	0	NA	0
Texarkana	R	NA	12	NA	0	NA	18
Uvalde	R	0	1	0	0	0	0
Wichita Falls	R	NA	10	NA	0	NA	3
Utah: Salt Lake City[c]	P	5	5	0(4)	0	9(4)	11
Vt: Burlington[c]	P	8	10	0(4)	0	12(4)	10
Va: Norfolk[c]	P	10	11	0(5)	0	10(5)	9
Wash: Seattle[c]	P	7	8	0(5)	0	10(5)	21
Spokane[c]	P	6	6	0(8)	0	8(8)	10
Benton County	P	0	0	0	0	0	6
Franklin County	R	NS	0	NS	0	NS	0
Sandpoint, Idaho	R	10	8	0	0	25	25
Skagit County	R	6	4	0	0	15	13
W.Va: Charleston[c]	P	10	12	0(3)	0	10(3)	5
Wisc: Milwaukee[c]	P	7	7	0(5)	0	7(5)	10
Wyo: Laramie[c]	P	3	4	0(3)	0	16(3)	10
CANADA:							
Alberta: Calgary	P	8	8	(d)		15	18
Edmonton	P	8	8	(d)		13	21
British Columbia: Vancouver	P	12	14	(d)		34	50
Manitoba: Winnipeg	P	9	8	(d)		25	25
New Brunswick: Frederickton	P	13	16	(d)		13	24
Newfoundland: St. Johns	P	15	21	(d)		30	43

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for January 1969 and 12-month period, February 1968 through January 1969—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium–90		Iodine–131		Cesium–137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)							
Nova Scotia: Halifax	P	11	11	(d)		14	23
Ontario: Ft. William	P	16	16	(d)		27	31
Ottawa	P	8	8	(d)		18	20
Sault Ste. Marie	P	15	15	(d)		29	33
Toronto	P	4	5	(d)		<10	16
Windsor	P	5	6	(d)		10	14
Quebec: Montreal	P	8	9	(d)		16	21
Quebec	P	12	12	(d)		25	29
Saskatchewan: Regina	P	6	7	(d)		14	17
Saskatoon	P	8	9	(d)		12	18
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	NS	4	NS	0	NS	2
Chile: Santiago	P	0	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	0
Jamaica: Kingston	P	4	0	0	0	45	108
Venezuela Caracas	P	0	0	0	0	0	0
Canal Zone: Cristobal[e]	P	2	2	0(4)	1	24(4)	12
Puerto Rico: San Juan[e]	P	6	5	0(3)	0	7(3)	9
PMN network average[f]		8	9	0	0	9	12

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones giving in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine–131: Colorado–25 pCi/liter; Michigan–14 pCi/liter; Oregon–15 pCi/liter
Cesium–137: Colorado–25 pCi/liter; New York–20 pCi/liter; Oregon–15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote.[c]

NA, no analysis.
NS, no sample collected.

140 data have been omitted from table 3 since levels at the great majority of the stations for January 1969 were below the respective practical reporting levels. Strontium–89 levels for all stations were nondetectable during this period. The following station averages reflect samples in which barium–140 was detected: Florida, Southeast (State, 14 pCi/liter and West (State) 14 pCi/liter.

Iodine–131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine–131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 21 pCi/liter in the United States for the month of January 1969 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.) representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium–137 monthly averages ranged from 0 to 105 pCi/liter in the United States for the month of January 1969 and the highest 12-month average was 111 pCi/liter (Southeast Florida) representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 results for individual samples were generally below the practical reporting level. The following station averages reflect samples in which iodine–131 was detected: Portland, Maine (PMN) 2 pCi/liter, 4 samples; Chattanooga, Tenn. (State) 3 pCi/liter, 4 samples.

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Radiological Health Services
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Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
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Radiological Health Section
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Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
Institutional Diet, *PHS*	April–June 1968	January 1969
Tri-City Diet, *HASL*	April–December 1967	June 1968

1. Estimated Daily Intake of Radionuclides in California Diets, November–December 1967 and January–September 1968

Bureau of Radiological Health
California State Department of Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals.)

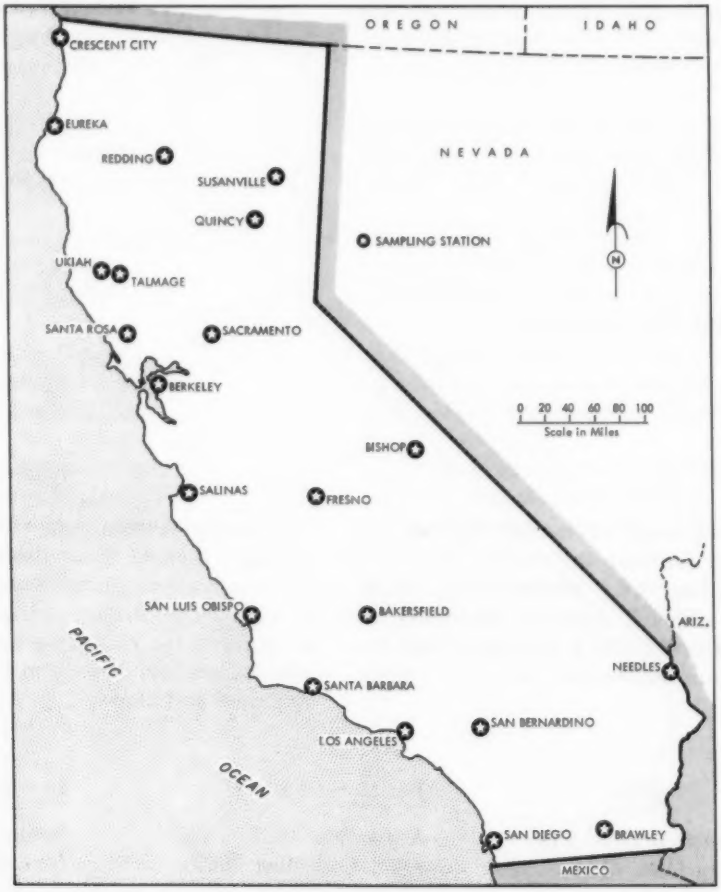

Figure 1. California diet sampling stations

Table 1. Estimated daily intake of radionuclides in California diets[a] November–December 1967

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)					Intake (g/capita·day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{54}Mn	K^c	Na	Ca
Bakersfield	2.1	ND	5	0.5	8	10	3.1	4.0	1.1
Berkeley	2.0	ND	6	[d].2	7	ND	2.5	3.7	NA
Bishop	NS								
Brawley	1.9	ND	6	1.0	7	9	2.7	3.4	1.0
Crescent City	2.2	ND	14	1.1	13	ND	3.0	4.3	1.2
Eureka	2.1	ND	9	1.2	15	ND	3.0	4.7	.9
Fresno	2.8	6	4	.9	[d]5	ND	3.4	3.9	.8
Los Angeles	1.7	ND	5	.5	8	ND	2.6	4.1	.9
Needles	2.2	ND	6	1.1	[d]5	ND	2.9	2.9	.9
Quincy	2.4	ND	8	1.6	[d]3	ND	3.4	3.6	1.3
Redding	2.0	ND	8	.5	[d]5	ND	2.8	2.8	.9
Sacramento	2.5	ND	4	1.9	33	ND	3.3	5.8	1.2
Salinas	2.3	ND	4	1.1	10	ND	3.0	4.8	.8
San Bernardino	1.7	ND	4	1.0	16	ND	3.0	3.7	.8
San Diego	1.4	ND	5	.6	5	ND	2.1	2.4	NA
San Luis Obispo	1.7	ND	5	1.4	8	ND	2.9	4.4	1.1
Santa Barbara	2.1	ND	7	1.3	ND	ND	3.0	3.5	1.0
Santa Rosa	1.7	ND	5	.6	13	ND	2.1	2.4	.7
Susanville	2.0	ND	7	1.0	14	ND	2.8	4.2	1.0
Ukiah	2.1	ND	6	.8	8	ND	2.8	3.7	1.0

[a] Based on analyses of Hospital Standard Diets located in listed cities. Intakes for barium-lanthanum–140, zirconium–95, and cerium 141,–144 were nondetectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium–40.
[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
ND, nondetectable.
NA, no analysis.
NS, no sample.

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium–89, strontium–90, radium–226, and stable calcium, strontium, and sodium.

Table 2. Estimated daily intake of radionuclides in California diets,[a] January–March 1968

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)							Intake (g/capita·day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141,144}Ce$	K^c	Na	Ca
Bakersfield	2.0	ND	4	0.8	17	0	0	0	3.8	3.8	1.2
Berkeley	1.8	ND	5	.8	9	ND	ND	ND	2.3	3.2	.6
Bishop	2.0	ND	8	1.1	12	ND	ND	ND	3.0	3.1	1.2
Brawley	NS										
Crescent City	2.0	ND	10	1.3	16	ND	8	ND	3.1	2.7	1.9
Eureka	2.2	ND	6	.6	30	ND	ND	ND	2.7	3.8	.7
Fresno	NS										
Los Angeles	2.3	ND	7	1.1	24	ND	ND	ND	3.5	4.1	1.1
Needles	2.4	ND	6	.7	22	ND	ND	ND	2.9	2.8	.9
Quincy	2.3	ND	4	1.4	19	ND	ND	ND	3.4	3.3	1.1
Redding	2.3	3	4	.6	11	ND	ND	ND	2.8	2.8	.8
Sacramento	2.6	ND	8	1.1	13	ND	ND	ND	3.3	5.1	1.3
Salinas	2.2	ND	4	.8	3	ND	7	ND	2.5	3.9	.8
San Bernardino	1.6	ND	3	1.5	11	ND	ND	ND	2.1	2.7	.6
San Diego	2.6	ND	12	.2	26	ND	ND	ND	3.8	3.5	1.4
San Luis Obispo	1.9	ND	7	1.3	18	ND	ND	ND	3.0	4.1	1.5
Santa Barbara	2.1	ND	8	.6	21	ND	ND	ND	3.0	3.3	.9
Santa Rosa	1.7	ND	4	1.1	12	ND	ND	ND	2.5	3.1	.9
Susanville	2.0	ND	6	1	18	ND	ND	ND	2.5	3.4	1.0
Ukiah	2.4	ND	7	1.0	18	ND	ND	ND	3.7	3.9	1.6

[a] Based on analyses of Hospital Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium–40.
ND, nondetectable.
NS, no sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (November–December 1967), table 2 (January–March 1968), table 3 (April–June 1968), and table 4 (July–September 1968).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. A summary of strontium–90 and cesium–137 intake trends in California diets from January 1964 through June 1968 is given in figures 2 and 3.

Table 3. Estimated daily intake of radionuclides in California diets[a] April–June 1968

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)				Intake (g/capita·day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	K[c]	Na	Ca
Bakersfield	2.1	ND	4	0.8	9	3.0	3.7	1.0
Berkeley	1.2	3	3	.3	15	1.5	2.0	.3
Bishop	1.7	ND	10	1.3	21	2.5	2.2	1.1
Brawley	1.8	ND	ND	.4	13	2.4	2.6	NA
Crescent City	2.6	16	18	1.4	21	3.5	4.9	1.3
Eureka	2.2	6	10	1.6	17	3.7	5.6	1.4
Fresno	2.3	ND	5	1.8	5	3.1	3.1	1.0
Los Angeles	1.8	ND	4	1.3	ND	2.5	2.7	.7
Needles	2.3	ND	6	.6	24	2.9	3.8	.8
Quincy	2.2	2	7	.9	23	2.9	4.1	.8
Redding	2.1	6	5	.9	19	2.3	3.1	.9
Sacramento	2.5	ND	6	1.3	24	3.2	4.9	1.2
Salinas	2.6	ND	6	1.0	29	3.6	5.7	.9
San Bernardino	1.7	ND	6	2.8	24	3.5	4.6	1.0
San Diego	2.2	ND	6	1.0	5	3.4	3.4	.9
San Luis Obispo	2.1	ND	5	.9	29	3.3	4.7	1.1
Santa Barbara	2.0	ND	5	1.0	11	2.0	2.5	.8
Santa Rosa	2.2	ND	6	2.1	13	2.6	3.1	1.0
Susanville	2.1	4	6	.8	15	2.5	3.6	1.1
Talmage	2.1	ND	7	1.2	15	3.1	3.7	1.3

[a] Based on analyses of Hospital Standard Diets located in listed cities. Intakes for manganese–54, zirconium–95 and cerium–141,–144 were nondetectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium–40.
[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
ND, nondetectable.
NA, no analysis.

Table 4. Estimated daily intake of radionuclides in California diets[a] July–September 1968

City	Consumption (kg/capita·day)[b]	Intake (pCi/capita·day)				Intake (g/capita·day)		
		^{89}Sr	^{226}Ra	^{137}Cs	^{95}Zr	K[c]	Na	Ca
Bakersfield	2.2	5	0.9	15	ND	3.3	4.1	1.1
Bishop	1.5	4	1.4	5	ND	2.3	2.0	NA
Brawley	1.8	7	1.7	34	17	2.5	3.7	1.0
Crescent City	2.6	10	2.0	20	ND	4.2	5.8	.8
Eureka	2.0	6	2.5	35	17	2.5	4.0	.9
Fresno	2.2	4	1.3	23	ND	NA	NA	1.1
Los Angeles	2.2	3	.5	22	ND	2.2	5.1	1.1
Needles	2.2	7	1.7	16	ND	3.1	5.0	1.0
Oakland	2.2	7	1.5	27	9	3.1	3.5	1.1
Quincy	2.0	6	1.4	41	20	2.8	3.0	.8
Redding	2.4	5	1.9	48	14	3.1	3.4	.8
Sacramento	2.4	4	1.5	19	ND	2.6	3.6	.8
Salinas	2.3	8	1.6	23	ND	5.0	5.5	1.7
San Bernardino	1.8	4	1.5	40	9	2.8	3.5	.8
San Diego	2.3	9	1.3	43	13	3.4	3.1	1.0
San Luis Obispo	2.3	7	1.6	45	18	3.4	4.0	1.2
Santa Barbara	2.1	5	1.1	36	13	2.8	3.0	.9
Santa Rosa	1.8	5	1.2	30	8	2.0	2.7	.8
Susanville	2.2	4	.8	22	ND	2.7	3.9	NA
Talmage	2.1	5	1.6	38	14	3.3	4.0	.8

[a] Based on analyses of Hospital Standard Diets located in listed cities. Intakes for strontium–89, manganese–54, and cerium–141,–144, were nondetectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium–40.
ND, nondetectable.
NA, no analysis.

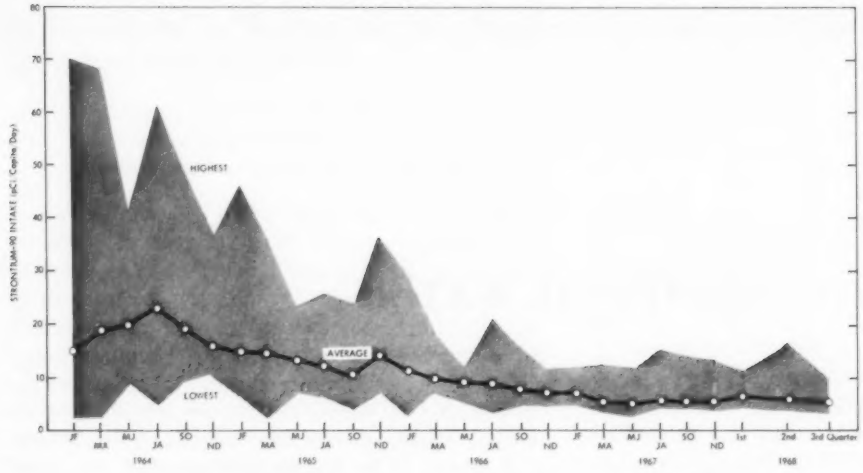

Figure 2. Averages and ranges of daily strontium–90 intake in California diets 1964–September 1968

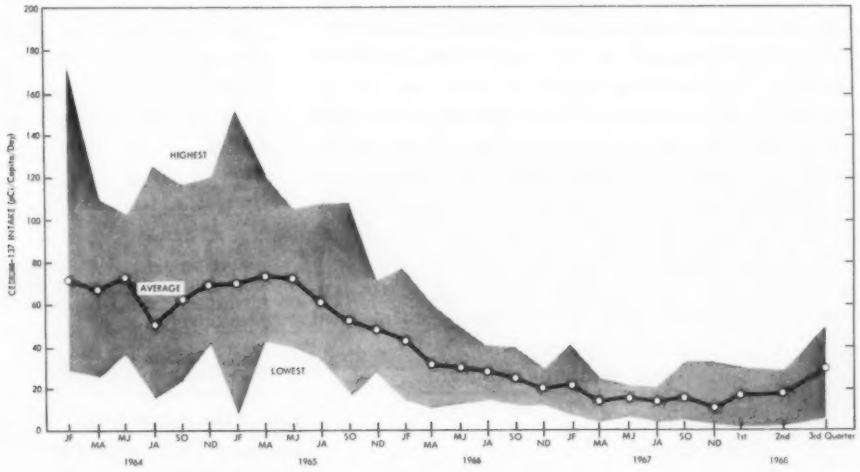

Figure 3. Averages and ranges of daily cesium–137 intake in California diets 1964–September 1968

REFERENCE

(*1*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 4:4 (October 1965) 2151 Berkeley Way, Berkeley 4, Calif.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March–June 1967	February 1968
July–October 1967	May 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	December 1968
Coast Guard	January–December 1967	November 1968
Florida	1965–1966	July 1968
Minnesota	July–December 1967	October 1968
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, *HASL*	January–June 1967	April 1968
Washington	July 1966–June 1967	August 1968

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in North Carolina Surface, Ground, and Cistern Waters[1] January-December 1967

Sanitary Engineering Division
Radiological Health Section
North Carolina State Board of Health

In recognition of the growing use of radioactive materials in the State of North Carolina, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health, with the cooperation of municipalities, began in June 1958 a program of measurement of radioactivity in surface waters used as public water supplies. Some 147 sampling points were established to sample raw surface water. In July 1962, the program was expanded to include the sampling of cistern water from Ocrocoke Island. Then, in January 1963, other types of environmental samples were also collected, two of which were treated water from surface water supplies and ground water from wells used as municipal water supplies.

All waters contain traces of radioactivity originating from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these materials are trace elements of potassium–40, radium, thorium, and uranium. Such trace elements are dissolved by water both on its way to and flowing in the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases, such as thoron and radon, are removed from the atmosphere. The combined radioactivity of these materials constitutes what is known as background radioactivity of the water. The total radioactivity would include both background radioactivity and contributions from fallout and other man-made sources.

A knowledge of the concentration of the background radioactivity as well as the total activity is an important factor in the appraisal of water quality, since standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background."

Sampling procedures

Grab samples of both treated and untreated surface water are collected on a monthly basis in 1-gallon polyethylene containers at nine water treatment plants. Twelve ground water and three cistern water supplies were routinely sampled in 1967. Cistern water samples are collected in 1-

[1] Summarized from "Background Radioactivity in Surface Water Supplies of North Carolina, 1958–1962" and "Environmental Radiation Surveillance 1967."

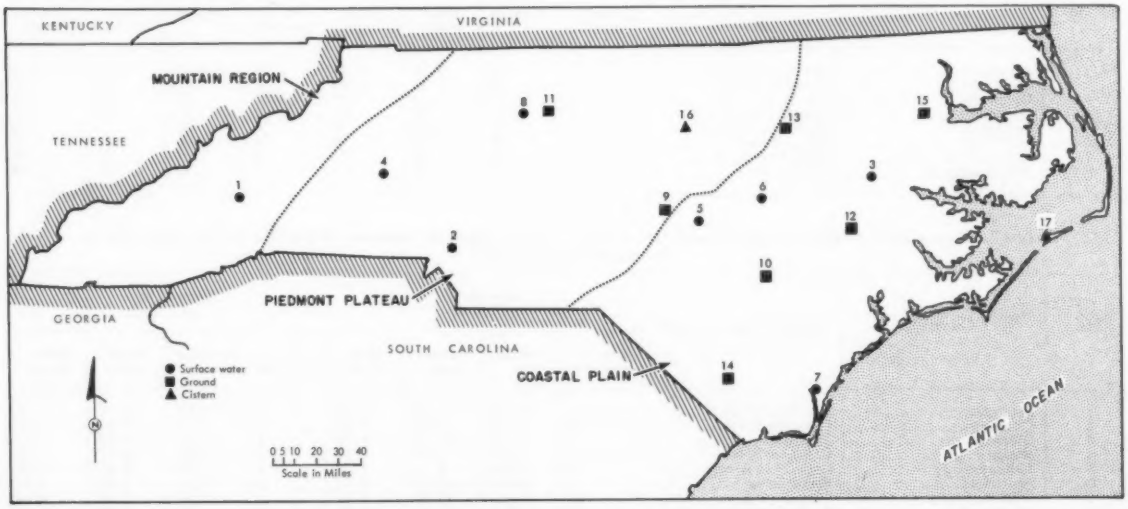

Figure 1. North Carolina water sampling stations

liter polyethylene containers and sent to the State laboratory for analysis as are all water samples. In the laboratory, samples are acidified with 2 ml of hydrochloric acid to prevent loss of radioactivity through precipitation and adhesion. The samples are then transferred to 3½ liter polyethylene Marinelli beakers for gamma-ray spectroscopy.

After scanning, 1 liter is filtered through Whatman No. 12 folded-filter paper. The filter paper, containing the suspended solids, is ashed in a muffle furnace at 600-degrees centigrade. The residue is transferred to a tared planchet, dried, weighed, and submitted for counting of gross alpha and gross beta radioactivity. The filtrate is evaporated to determine the gross alpha and gross beta radioactivity of the dissolved solids.

The alpha and beta radioactivity counting system is a low background, thin-window, gas-flow proportional counter utilizing a 2-¼ inch detector. Except in the case of ground water, a strontium–89 and strontium–90 determination is made on water samples when the gross beta radioactivity exceeds 5 pCi/liter. If gross beta radioactivity above 5 pCi/liter is detected in a ground water sample, it is analyzed by gamma-ray spectroscopy for radium.

Discussion

All results may be interpreted on the basis of the PHS Drinking Water Standards (*1*), which state that in the absence of strontium–90 and alpha-particle emitters, a water supply is acceptable if the gross beta radioactivity does not exceed 1,000 picocuries per liter of water. This value relates to average intake from water over a long period of time and not for transient conditions.

Table 1 gives the gross alpha radioactivity in raw and treated surface waters as well as maximum and minimum values recorded during 1967. The first column consists of code numbers which indicate the geographical positions of the sampling stations as shown in figure 1. Gross alpha radioactivity was somewhat greater in raw water than in treated water at most stations.

Table 2 gives the average gross beta radioactivity in raw and treated surface waters as well as maximum and minimum values. Maximum beta radioactivity values were detected almost equally between raw and treated water. Locations for sampling gross alpha and beta radioactivity in surface waters are spread across North Carolina in the Mountain, Piedmont, and Coastal regions. Table 3 gives the gross beta radioactivity in North Carolina ground waters.

Table 1. Gross alpha radioactivity found in surface waters used as sources of public water supplies in North Carolina, 1967

Code	Location	Source of water supply	Raw water (pCi/liter)				Treated water (pCi/liter)			
			No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
1	Asheville	Bee Tree Creek	6	0.19	0.58	0.02	6	0.03	0.05	0.02
2	Charlotte	Catawba River	7	.15	.45	.00	7	.02	.03	.00
3	Greenville	Tar River	7	.56	1.34	.07	7	.20	.62	.04
4	Hickory	Catawba River	7	.15	.18	.02	6	.11	.39	.02
5	Lillington	Cape Fear River	5	.81	1.97	.02	4	.07	.18	.02
6	Smithfield	Neuse River	7	.36	.70	.10	7	.06	.17	.00
7	Wilmington	Cape Fear River	8	.23	.56	.08	8	.21	.89	.00
8	Winston-Salem	Yadkin River	7	.44	1.25	.12	7	.17	.79	.02

Table 2. Gross beta radioactivity found in surface waters used as sources of public water supplies in North Carolina, 1967

Code	Location	Source of water supply	Raw water (pCi/liter)				Treated water (pCi/liter)			
			No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
1	Asheville	Bee Tree Creek	6	3.14	6.59	0.95	6	3.00	8.11	1.14
2	Charlotte	Catawba River	7	2.65	4.81	.86	7	3.13	7.66	1.94
3	Greenville	Tar River	7	4.47	10.72	1.78	7	4.75	8.08	3.02
4	Hickory	Catawba River	7	2.84	5.04	1.91	7	3.99	9.77	1.61
5	Lillington	Cape Fear River	5	5.50	6.11	4.53	4	5.79	9.42	3.69
6	Smithfield	Neuse River	7	3.67	6.09	2.44	7	5.31	8.76	2.94
7	Wilmington	Cape Fear River	8	9.45	50.26	1.92	8	3.43	3.98	2.90
8	Winston-Salem	Yadkin River	7	5.74	21.24	1.74	7	2.21	2.79	1.83

Table 3. Gross beta radioactivity in ground water in North Carolina, 1967

Code	Location	Beta radioactivity (pCi/liter)			
		No. of samples	Average	Maximum	Minimum
9	Broadway	4	4.07	4.60	3.08
10	Clinton	4	7.56	8.80	6.42
11	Gibsonville	4	1.73	2.77	.81
12	Kinston	4	10.41	12.77	8.22
13	Springhope	5	1.45	1.82	1.13
14	Whiteville	3	6.25	7.22	4.41
15	Windsor	5	8.03	9.17	6.75

On some of the islands situated along the eastern seaboard of North Carolina, and at some private residences in Durham County, drinking water is obtained from small cistern water supplies. The cistern supplies are characteristically constructed with roof prewash valves which permit the diversion of the first runoff and then allow the balance of the rainwater to pass into the cistern. Table 4 presents the results for samples taken on Ocracoke Island and in Durham County.

REFERENCE

(1) PUBLIC HEALTH SERVICE. Drinking Water Standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 4. Gross alpha and beta radioactivity in cistern water in North Carolina, 1967

Code	Location	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
16	Durham County	1	0.45			1	5.54		
17	Ocracoke Island	14	.41	1.40	0.02	14	6.80	19.83	1.67

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network January 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform field estimates on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during January 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, January 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation			
							Number of samples	Total depth (mm)	Field estimation of deposition	
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	22	6	0	2	Sept 68	3	42	3	42	3
Alaska:	Adak	26	2	1	2	Apr 68	(c)				
	Anchorage	4	0	0	0	Oct 68	(c)				
	Attu Island	21	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	19	0	0	0	Dec 68	5	23	5	23	0
	Kodiak	18	1	0	0	Jan 69	(c)				
	Nome	(b)				May 69	(c)				
	Point Barrow	25	0	0	0	Apr 69	(c)				
	St. Paul Island	21	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	21	17	0	6	Dec 68	(c)				
Ark:	Little Rock	6	2	0	1	Oct 68	(c)				
Calif:	Berkeley	22	2	0	0	Jan 69	9	187	9	187	0
	Los Angeles	(b)				May 69	(c)				
C.Z:	Ancon	17	0	0	0	Jan 69	(c)				
Colo:	Denver	22	7	1	2	Jan 69	(c)				
Conn:	Hartford	22	1	0	0	Nov 68	6	26	6	26	0
Del:	Dover	21	1	0	0	Sept 68	(c)				
D.C.:	Washington	(b)				Apr 69	(c)				
Fla:	Jacksonville	19	2	0	1	Oct 68	3	40	3	40	18
	Miami	17	1	0	0	Nov 68	4	129	4	129	0
Ga:	Atlanta	22	2	1	1	Aug 68	3	87	3	87	83
Guam:	Agana	(b)				Sept 68	(c)				
Hawaii:	Honolulu	30	1	0	1	Mar 69	6	141	(d)		
Idaho:	Boise	15	1	0	0	Mar 69	10	73	7	66	8
Ill.	Springfield	22	1	0	0	Apr 69	(c)				
Ind:	Indianapolis	21	1	0	1	Aug 68	9	148	9	148	179
Iowa:	Iowa City	22	0	0	0	Jan 69	(c)				
Kans:	Topeka	22	1	0	0	Oct 68	4	9	4	9	1
Ky:	Frankfort	11	1	0	1	Apr 69	(c)				
La:	New Orleans	20	1	0	0	Apr 69	3	52	(d)		
Maine:	Augusta	9	2	0	1	May 69	6	83	4	64	0
Md:	Baltimore	23	1	0	0	Nov 68	5	35	5	35	15
	Rockville	10	0	0	0	Mar 69	(c)				
Mass:	Lawrence	21	0	0	0	Jan 69	2	32	2	32	9
	Winchester	22	1	0	0	Feb 69	6	54	6	54	0
Mich:	Lansing	12	5	0	2	Mar 69	(c)				
Minn:	Minneapolis	22	1	0	0	Sept 68	9	43	9	43	2
Miss:	Jackson	19	2	0	0	May 69	1	6	1	6	8
Mo:	Jefferson City	21	1	0	0	Aug 68	7	113	7	113	0
Mont:	Helena	21	4	0	1	Feb 69	10	20	10	20	26
Nebr:	Lincoln	22	2	0	0	Aug 68	(c)				
Nev:	Las Vegas	21	2	0	1	Nov 68	(c)				
N.H.:	Concord	22	1	0	0	Apr 69	(c)				
N.J:	Trenton	21	1	0	0	May 69	4	54	4	54	29
N. Mex:	Santa Fe	16	1	0	1	Feb 69	3	11	3	11	6
N.Y:	Albany	19	1	0	1	Aug 68	7	37	7	37	39
	Buffalo	22	1	0	0	Jan 69	(c)				
	New York City	21	2	0	0	Feb 69	(c)				
N.C:	Gastonia	17	13	1	4	Jan 69	3	21	(d)		
N. Dak:	Bismarck	23	0	0	0	Apr 69	9	19	9	19	0
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	20	1	0	0	May 69	7	85	7	85	0
	Painesville	23	1	0	1	Nov 68	8	12	8	12	6
Okla:	Oklahoma City	20	2	0	1	Mar 69	1	6	1	6	0
	Ponca City	22	2	0	1	Nov 68	4	15	4	15	0
Ore:	Portland	21	2	0	0	Aug 68	15	130	15	130	28
Pa:	Harrisburg	19	1	0	0	Aug 68	(c)				
P.R:	San Juan	(b)				May 69	(c)				
R.I:	Providence	19	2	0	0	Mar 69	2	30	2	30	13
S.C:	Columbia	12	2	0	0	Feb 69	2	70	2	70	40
S. Dak:	Pierre	19	2	0	1	Dec 68	(c)				
Tenn:	Nashville	17	1	0	0	Mar 69	10	89	10	89	5
Tex:	Austin	22	8	1	4	Sept 68	1	5	(d)		
	El Paso	19	9	1	4	Apr 69	(c)				
Utah:	Salt Lake City	31	1	0	0	May 69	8	35	8	35	5
Vt:	Barre	19	1	0	1	Oct 68	8	39	8	39	0
Va:	Richmond	15	1	0	0	Oct 68	1	10	1	10	1
Wash:	Seattle	25	1	0	0	Oct 68	13	80	(d)		
	Spokane	19	0	0	0	Sept 68	2	8	2	8	3
W. Va:	Charleston	21	1	0	1	Feb 69	10	31	10	31	6
Wisc:	Madison	21	1	0	0	Oct 68	11	51	10	49	57
Wyo:	Cheyenne	21	4	1	2	Nov 68	2	5	2	5	9
Network summary		1,295	17	0	1		6	52	6	51	16

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

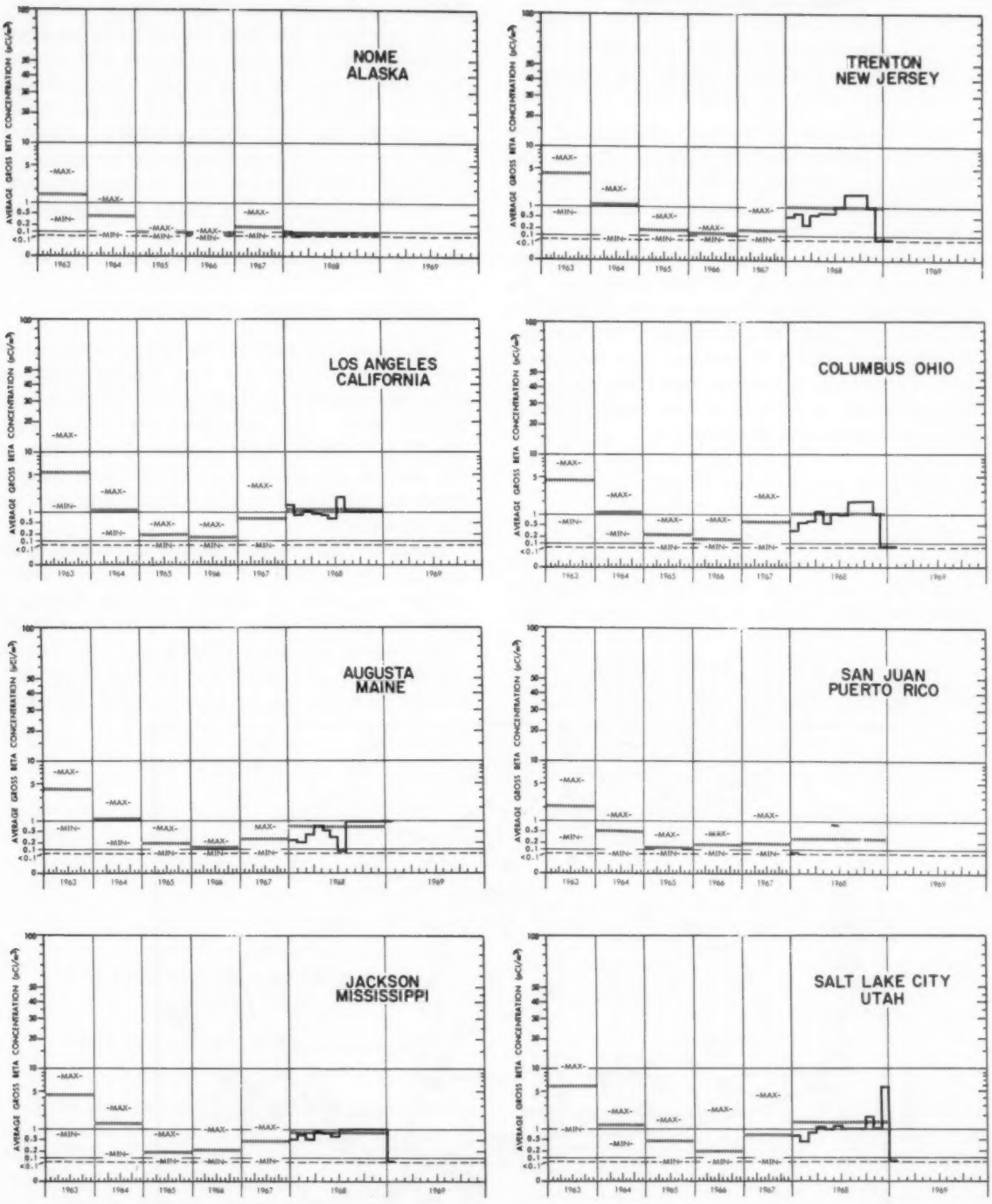

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–January 1969

2. Canadian Air and Precipitation Monitoring Program, January 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorologic Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650-cubic meters of air drawn through a high efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa for analysis.

To determine the beta radioactivity, a 2-inch diameter disk is cut from each filter and counted with a thin-end window, gas flow, Geiger–Mueller counter system calibrated with a strontium–yttrium–90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for January 1969 are presented in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples depending upon the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter together with the poly-

[1] Prepared from February 1969 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

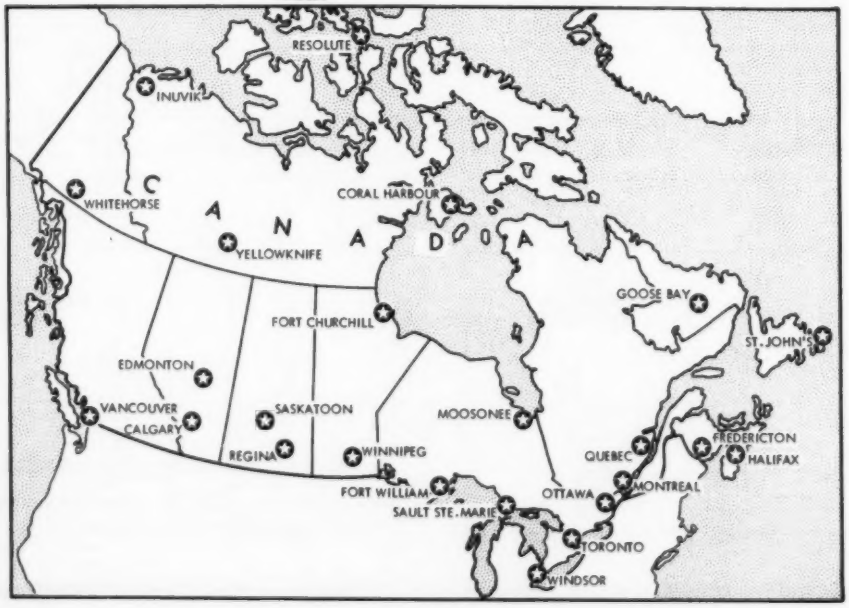

Figure 3. Canadian air and precipitation sampling stations

ethylene liner is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin-end window Geiger–Mueller counter calibrated with a strontium–yttrium–90 source.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. The January 1969 gross beta deposition values are given in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, January 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.2	0.0	0.1	NA	NA
Coral Harbour	31	.1	.0	.1		
Edmonton	31	.1	.0	.1		
Ft. Churchill	31	.1	.0	.0		
Ft. William	31	.1	.0	.1		
Fredericton	31	.1	.0	.0		
Goose Bay	31	.1	.0	.0		
Halifax	31	.1	.0	.0		
Inuvik	31	.1	.0	.0		
Montreal	29	.2	.0	.0		
Moosonee	30	.1	.0	.0		
Ottawa	31	.1	.0	.1		
Quebec	31	.1	.0	.0		
Regina	30	.1	.0	.1		
Resolute	30	.1	.0	.1		
St. John's, Nfld	30	.1	.0	.0		
Saskatoon	31	.1	.0	.1		
Sault Ste. Marie	19	.1	.0	.1		
Toronto	30	.1	.0	.1		
Vancouver	31	.1	.0	.1		
Whitehorse	31	.1	.0	.1		
Windsor	31	.2	.0	.1		
Winnipeg	31	.1	.0	.1		
Yellowknife	31	.1	.0	.1		
Network summary	725	0.2	0.0	0.1	NA	NA

NA, no analysis reported.

3. Pan American Air Sampling Program January 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The January 1969 air monitoring results from the participating countries are given in table 3.

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, January 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	NS			
Bolivia:	La Paz	19	0.26	0.01	0.08
Chile:	Santiago	31	.33	.08	.21
Colombia:	Bogata	9	.03	.01	.02
Ecuador:	Guayaquil	21	.27	.08	.15
Guyana:	Georgetown	18	.08	.00	.03
Jamaica:	Kingston	22	.11	.01	.03
Lima:	Peru	NS			
Venezuela:	Caracas	20	.05	.00	.03
West Indies:	Trinidad	18	.05	.01	.02
Pan American summary		158	0.33	0.00	0.09

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no samples.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site January-June 1965

Southwestern Radiological Health Laboratory, DHEW, and
Nevada Operations Office, AEC

Under a memorandum of understanding between the U.S. Atomic Energy Commission and the Public Health Service, DHEW, the Southwestern Radiological Health Laboratory (SWRHL) of the Bureau of Radiological Health, performed radiological surveillance in the public areas surrounding the Nevada Test Site (NTS) during the period, January through June 1965. During this period, 17 announced underground nuclear tests were conducted at the NTS and five reactor experiments were conducted at the Nuclear Rocket Development Station (NRDS), a part of the NTS complex.

Operational procedures

Both ground and aerial monitoring capabilities were maintained throughout this period. Mobile ground monitoring teams were positioned in offsite areas prior to each test, and an aerial monitoring team was prepared to track any radioactive releases to determine relative radiation intensities and to indicate cloud position, speed, and direction. Monitoring teams were equipped with Eberline E–500B, Precision Model 111 Standard "Scintillator," and Victoreen Radector Model No. AGB–50B–SR portable survey instruments. Eberline RM–11 gamma ray, exposure-rate recorders were also utilized to document cloud passage at fixed ground locations.

The SWRHL environmental surveillance program collected air, milk, water, and vegetation samples. Two C–45 aircraft were used as necessary for radioactive cloud sampling by cryogenic, electrostatic precipitator, and mass air sampling techniques. The SWRHL Air Surveillance Network (ASN) expanded from 59 to 97 stations during this period, has given coverage to every State west of the Mississippi River except Montana and North Dakota (figures 1 and 2). The air sampler used in the ASN was a Gelman "Tempest" equipped to use a 4-inch diameter Whatman-541 filter paper and an MSA charcoal cartridge. The established milk sampling program from both commercial dairies and private producers continued throughout the 6-month period. A total of 136 routine milk samples were collected from 31 sources. Water samples were also collected on a routine basis from both potable and nonpotable supplies. A total of 170 water samples were col-

[1] This article is a summary of report No. SWRHL–23r, Offsite Surveillance Activities of the Southwestern Radiological Health Laboratory from January through June 1965 (July 1, 1966) by the Southwestern Radiological Health Laboratory, Las Vegas, Nev.

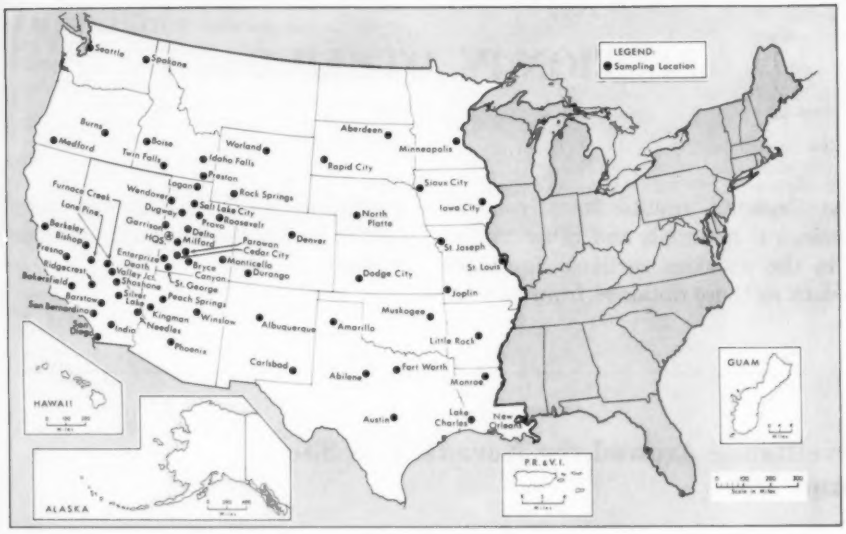

Figure 1. Air surveillance network stations other than Nevada

Figure 2. Air surveillance network stations in Nevada

lected from 39 sources. Milk and water samples were normally collected on a monthly basis unless special sample collection was indicated (figure 3 shows routine milk and water sampling locations). Vegetation samples, the results of which are used to delineate any fallout pattern, were collected only after a known release of radioactivity.

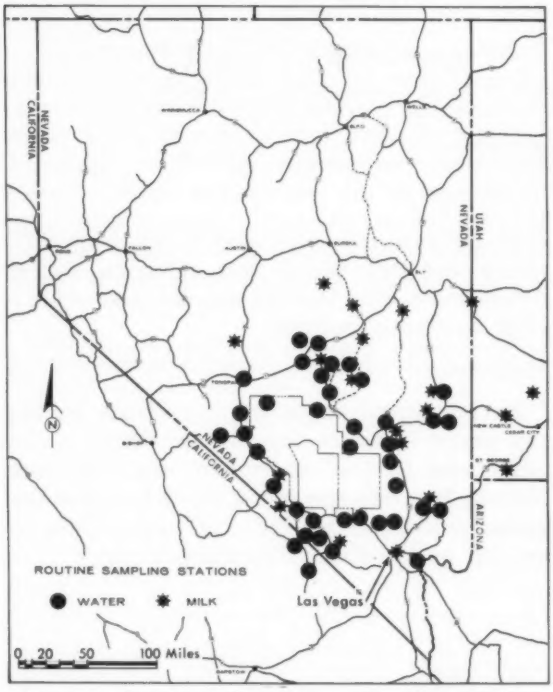

Figure 3. Routine milk and water sampling stations

Approximately 150 residents in the offsite area wore film badge dosimeters throughout this period; 75 permanent film badge stations were also used. The DuPont type 555 film in the badge has a 30 mR lower limit of detection.

A PHS medical officer was available to investigate cases of a medical nature which might have occurred as a result of the test series. Similarly, an Army veterinarian and a PHS veterinarian were available to conduct wildlife or domestic livestock investigations.

Analytical procedures

Samples were returned to the SWRHL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman wide beta low-background, proportional counter system. Selected particulate filters, all charcoal cartridges, water, and milk samples were analyzed for gamma ray emitting isotopes using a 4-inch by 4-inch NaI (T1) crystal coupled to a TMC Model 404C gamma-ray pulse height analyzer. The lower limit of detection for gamma-ray emitters in milk samples was 20 pCi/liter at the time of count. Gamma-ray spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides.

Results

Four underground tests released radioactive effluent which was detected in offsite populated areas. These were the Alpaca event on February 12; the Project Palanquin, a Plowshare cratering experiment, on April 14; the Tee event on May 7; and the Diluted Waters event on June 16, 1965. In addition, five reactor experiments conducted at the NRDS also released radioactive effluent to the offsite environment. These were the Kiwi Transient Nuclear Test (TNT) on January 12; the NRX–A3 Experimental Plans 4, 5, and 6 on April 23, May 20, and May 28; and the Phoebus 1A on June 25, 1965. The highest levels of radioactivity detected offsite are shown in tables 1 to 3.

Table 1. Highest levels of radioactivity in off-NTS areas January–June 1965

Date (1965)	Highest ground monitoring results from different events	
	Location	Net gamma radioactivity reading (mR/hr)
January 12	1.5 miles west of Lathrop Wells, Nev. (unpopulated)	70
April 14	Stone Cabin Ranch, Warm Springs, Nev.	3
June 25	Queen City Summit, Nev. (unpopulated)	0.061

The highest concentration of fresh fission products found in a potable water sample was 70 pCi/liter of iodine–131 found in tap water collected on April 18, 1965, near Warm Springs, Nev. The only film badges indicating positive exposures were the permanent station badges collected following the Project Palanquin. The maximum exposure on any badge was 45 mR at the Stone Cabin Ranch near Warm Springs, Nev., exposed from March 31, 1965 to May 6, 1965. Selected offsite residents from the downwind area were brought to the SWRHL for whole body counting following the Project Palanquin. The maximum measured thyroid exposure was 160 mrad. It should be noted that the radioactivity in many of the samples collected during this 6-month period

Table 2. Highest levels of air sampling results in off-NTS areas (based on iodine-131) January–June 1965

Date (1965)	Location	Gross beta radioactivity (pCi/m³)	Radionuclide analysis (pCi/m³)	
			Iodine-131	Iodine-133
January 12 (1045–1220 hrs)	Hwy. 95, 1.5 miles west of Lathrop Wells, Nev. (unpopulated)	210,000	[a] 630 (F) [b] 150 (C)	13,000 (F) 290 (C)
April 14 (1115–1235 hrs)	Hwy. 6,8-miles east of Tonopah Test Range, Nev. (unpopulated)	87,000	8,200 (F) 4,200 (C)	33,000 (F) 32,000 (C)
April 14 (0412–1615 hrs)	Clark Station, Nev.	23,000	3,400 (F) 670 (C)	10,000 (F) 6,100 (C)

[a] F–Whatman-541 particulate filter to collect particulate fission products.
[b] C–MSA charcoal cartridge, secondary to particulate filter, for collection of radioactive gases, primarily iodine.

Table 3. Highest levels of milk sample results in off-NTS areas, January–June 1965

Date (1965)	Location	Iodine-131 concentration (pCi/liter)
April 18	Martin Ranch, Eureka, Nev.	11,000
April 19	Martin Ranch, Eureka, Nev.	11,000
April 20	Pasquale-Richards Ranch, Paradise Valley, Nev.	5,500 (highest value found at farm where children were living).

[a] These concentrations are peak levels that occurred a few days after the event. The radioactivity levels returned to <20 pCi/liter within a month.

could not be directly attributed to any single NTS release and that fallout from a foreign nuclear detonation of May 14, 1965 was also observed in a large number of samples.

Conclusions

Environmental radiation surveillance during this period indicates that no individual in the offsite area received an exposure resulting from Nevada Test Site operations, which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory, the Neutron Devices Department (formerly known as the Pinellas Peninsula Plant) and the Mound Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory[2] January–June 1968

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January–June 1968," University of Chicago, Lemont, Ill.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in air-filter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium–7, produced continuously in the upper atmosphere by cosmic-ray interactions. The variation in total beta radioactivity during the year can be correlated with the concentrations of the individual gamma-ray emitters. An increase by a factor of three from December 1967 to January 1968, was due to an increase in the amounts of

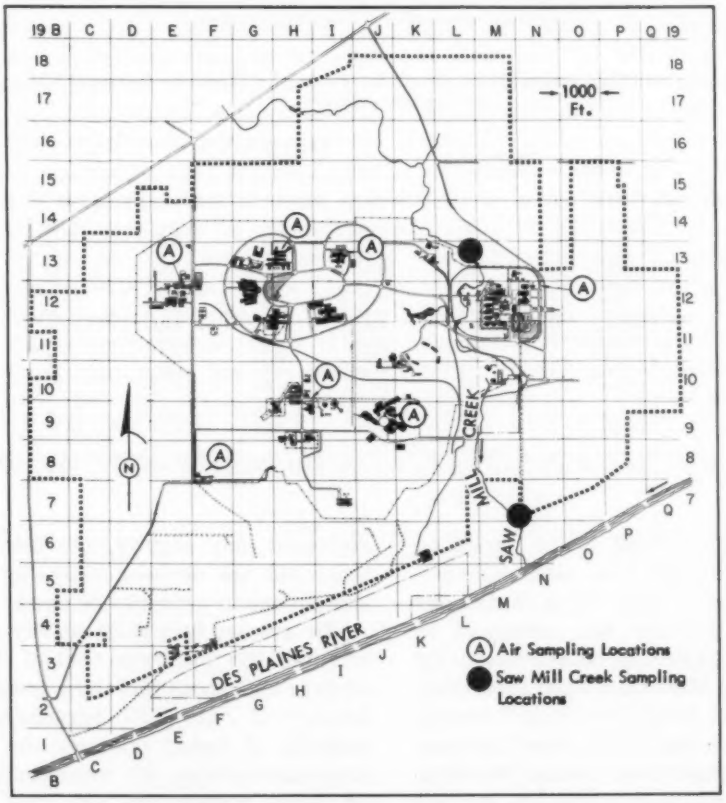

Figure 1. Sampling locations on the site of Argonne National Laboratory

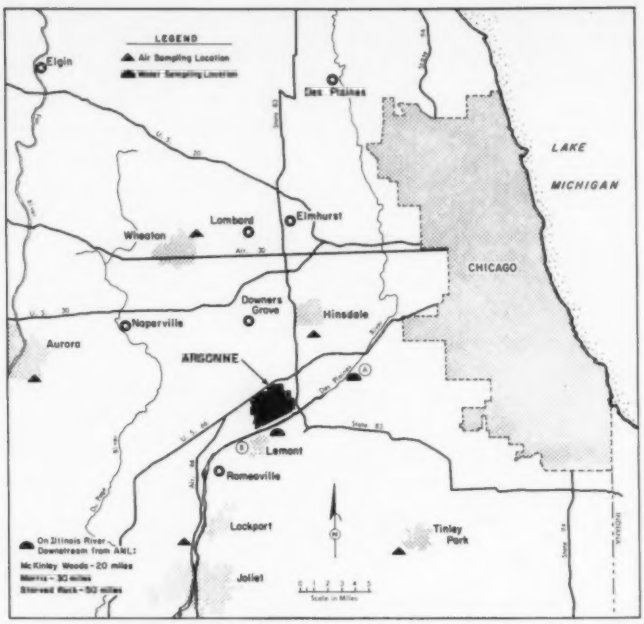

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples, Argonne National Laboratory January–June 1968[a]

Date (1968)	Location	Number of samples	Alpha radioactivity (pCi/m³)			Beta radioactivity (pCi/m³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Onsite	26	0.0039	0.0019	0.0061	0.16	0.08	0.33
	Offsite	23	.0049	.0025	.0082	.16	.08	.25
February	Onsite	24	.0042	.0027	.0062	.23	.10	.49
	Offsite	20	.0043	.0008	.0062	.24	.14	.38
March	Onsite	26	.0051	.0019	.0101	.28	.19	.49
	Offsite	22	.0051	.0027	.0092	.32	.21	.51
April	Onsite	27	.0045	.0024	.0073	.29	.19	.51
	Offsite	23	.0053	.0030	.0080	.29	.13	.46
May	Onsite	26	.0047	.0020	.0081	.24	.14	.34
	Offsite	22	.0050	.0017	.0111	.24	.14	.36
June	Onsite	24	.0046	.0023	.0084	.25	.11	.38
	Offsite	20	.0060	.0014	.0126	.26	.11	.41
Summary	Onsite	153	0.0045	0.0019	0.0101	0.24	0.08	0.51
	Offsite	130	0.0051	0.0008	0.0126	0.25	0.08	0.51

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioacticity due to radon and thoron decay products.

the short- and medium-lived fission products, such as barium–lathanum–140, zirconium–niobium–95, and ruthenium–103. Much of the zirconium–niobium–95 activity was contained in discrete, insoluble particles. The beta radioactivity reached a maximum in March and April 1968, when the zirconium–niobium–95 and beryllium–7 concentrations were also at a maximum. Since the concentrations of the longer-lived fission products, cerium–144 and ruthenium–rhodium–106, did not decrease from March to June and the beryllium–7 decreased only slightly, the total beta radioactivity did not decrease markedly as the barium and zirconium activities decayed.

The average beta radioactivity during January to June 1968 was twice that of the 1967 annual average and about one-third greater than during January to June 1967, because of the increased quantity of fission products. In particular, the zirconium–niobium–95 concentration was about ten times greater this year than in 1967. Precipitation was also collected and analyzed for

fission products, and the same radioisotopes found in the air-filter samples were also present. The shorter-lived fission products, for example, were present in precipitation only early in the year.

Sampling on charcoal, specifically for gaseous radioiodine, was conducted continuously on the site. No activity above the minimum detectable concentration of 0.1 pCi/m³ was detected during this time period.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500-yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during January–June 1968 are given in table 2.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 3. The average uranium concentrations below the outfall was about 2.4 pCi/liter, while the plutonium and thorium concentrations averaged less than the minimum detectable amount.

In addition to the natural beta radioactivity in the creek, beta radioactivity from fallout was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the first half of 1968 is estimated to be approximately 20 pCi/liter, compared to 10 pCi/liter in 1967. The concentration of fallout radioactivity was about twice that during 1967.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above the mouth of Sawmill Creek and weekly below the mouth to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 4. The average concentrations were very similar at both locations, indicating that Sawmill Creek water had no significant effect on the radioactivity in the river. The alpha radioactivity was normal and similar to that found in pre-

Table 2. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne, January–June 1968

Date (1968)	Location *	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Upstream	2	4.0	3.5	4.5	11	8.8	13
	Downstream	12	1.6	0.9	3.3	31	11	50
February	Upstream	2	3.0	2.4	3.6	10	9.1	11
	Downstream	12	2.9	2.1	4.4	32	15	45
March	Upstream	2	3.7	3.3	4.1	10	9.6	11
	Downstream	15	4.2	1.7	9.9	15	13	20
April	Upstream	2	3.6	2.8	4.3	21	8.7	33
	Downstream	12	2.2	1.3	3.2	39	15	93
May	Upstream	2	2.2	2.0	2.3	14	11	17
	Downstream	15	3.6	1.6	9.6	34	15	75
June	Upstream	2	2.2	1.9	2.5	18	16	20
	Downstream	12	2.1	2.0	2.4	27	14	56
Summary	Upstream	12	3.1	1.9	4.5	14	8.7	33
	Downstream	78	2.8	0.9	9.9	30	11	93

* Relative sampling location with respect to Argonne waste water outfall (figure 1).

Table 3. Alpha-emitting elements in Sawmill Creek water, Argonne January–June 1968

Element	Location [a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard
			Average	Minimum	Maximum	
Uranium	Upstream	6	2.0	1.2	2.8	0.005
	Downstream	36	3.4	1.2	12.0	.009
Plutonium	Upstream	6			<0.05	
	Downstream	12	<0.05	<0.05	.18	<0.001
Thorium	Upstream	6			<0.05	
	Downstream	12			<0.05	

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 4. Average radioactivity in Des Plaines and Illinois River water, Argonne, January–June 1968

Location	Concentration (pCi/liter)	
	Non-volative alpha radioactivity	Non-volative beta radioactivity
Des Plaines River [a] (above Sawmill Creek)	4.4	13
Des Plaines River [b] (below Sawmill Creek)	3.8	15
Illinois River [c]	2.9	8

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average for samples collected at three locations (McKinley Woods State Park, Morris, and Starved Rock State Park) on May 12, 1968.

vious years. The average beta radioactivity was about equally divided between fallout and natural radioactivity.

The Illinois River was sampled at McKinley Woods on June 6 and the total radioactivity in these samples was similar to those found in other bodies of water in the area and to the radioactivity found previously at these same locations.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium–89, iodine–131, and barium–140, were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 3 pCi/liter for the other two radionuclides. The strontium–90 and cesium–137 concentrations are given in table 5. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The cesium–137 concentrations during this period decreased to less than one-half of the 1967 concentrations, while the strontium-90 concentrations were nearly the same. Iodine–131 and barium–140 were not detected during this period.

Table 5. Fission product concentrations in milk January–June 1968

Date collected (1968)	Cesium–137 (pCi/liter)	Strontium–90 (pCi/liter)
January 3	30	5.8
February 7	30	5.8
March 6	35	7.7
April 4	30	8.8
May 2	40	8.6
June 5	60	7.0
Average	39	7.3

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	March 1968
July–December 1967	August 1968

2. Neutron Devices Department[3] July–December 1967

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department, shown in figure 3 is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plants's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 4 of 205 samples analyzed showed detectable concentrations of tritium (900 nCi/liter).[4] The maximum concentration, 1,300 nCi/liter, which was detected on July 27, 1967, amounted to 43 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for July–December 1967 was less than 1.2 percent of the AEC Radiation Protection Standard for continuous nonoccupational exposure.

[3] Summarized from "Environmental Monitoring, July 1 through December 31, 1967" General Electric Company, Neutron Devices Department, St. Petersburg, Fla., formerly known as the Pinellas Peninsula Plant.

[4] Expressions in parentheses indicate limits of detectability in the respective environmental samples.

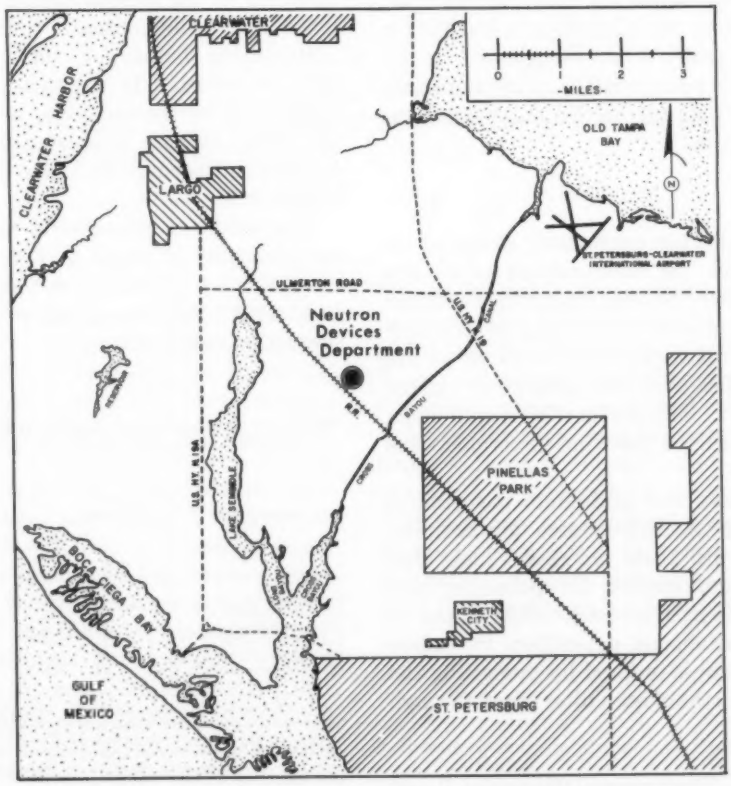

Figure 3. Location of the Neutron Devices Department

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (90 nCi/liter) in the 61 surface water samples analyzed during the sampling period.

Milk sampling results

Seventeen samples of raw milk were collected from local dairy farms and analyzed by the Florida State Board of Health during the second half of 1967. No detectable concentrations (90 nCi/liter) of tritium were evident.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	July 1967
January–June 1967	February 1968

3. Mound Laboratory[5] January–June 1968

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air in the network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

Airborne polonium and plutonium particulates are collected with a high-volume air sampler. The filter paper are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. Plutonium is isolated by processing the remaining three fourths of each filter paper through a resin column.

Airborne tritium is monitored by drawing air through a calcium chloride drying tube. The water collected in the sample tube is distilled and analyzed for tritium content.

Beginning January 1, 1967, all particulate air samples collected in the same zone, in the same range, and on the same day are combined before processing and are considered as one sample. This is done to improve the lower detectable limit for plutonium.

The results of the airborne monitoring program are presented in tables 6, 7, and 8. The average concentration of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 6. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1968

Range (miles)	Number of samples	Concentration[a] (fCi/m³)		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	24	440.2	43.0	0.21
0–3 (downwind)	24	404.2	45.4	.23
3–5 (downwind)	24	396.6	44.1	.22
5–10 (downwind)	24	331.5	37.9	.19
10–15 (downwind)	24	312.7	37.5	.19
15–20 (downwind)	24	236.8	28.3	.14

[a] Lowest detectable level (LDL) for polonium-210 in air is 8.0 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20,000 fCi/m³.

[5] Summarized from "Environmental Monitoring Report January–June 1968" (MLM–1522).

Table 7. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, January–June 1968

Range (miles)	Number of samples	Concentration [a] (nCi/m³)		Average as percent of AEC standards [b]
		Maximum	Average	
0–3 (upwind)	24	37.9	14.6	20.86
0–3 (downwind)	24	36.5	10.9	15.57
3–5 (downwind)	24	81.1	16.5	23.57
5–10 (downwind)	23	55.0	16.1	23.00
10–15 (downwind)	23	36.5	14.8	21.14
15–20 (downwind)	22	54.4	11.3	16.14

[a] Lowestest detectable limit (LDL) for plutonium-238 in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for plutonium-238 in air is 70 fCi/m³.

Table 8. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1968

Range (miles)	Number of samples	Concentration [a] (fCi/m³)		Average as percent of AEC standards [b]
		Maximum	Average	
0–3 (upwind)	23	16.55	4.85	2.42
0–3 (downwind)	23	12.95	3.81	1.90
3–5 (downwind)	23	10.95	3.14	1.57
5–10 (downwind)	23	12.85	3.74	1.87
10–15 (downwind)	23	10.15	3.49	1.74
15–20 (downwind)	23	16.90	4.07	2.03

[a] Lowest detectable limit for tritium in air is 2.00 nCi/m³. All values which were not detectable were set equal to this value when average values were calculated.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

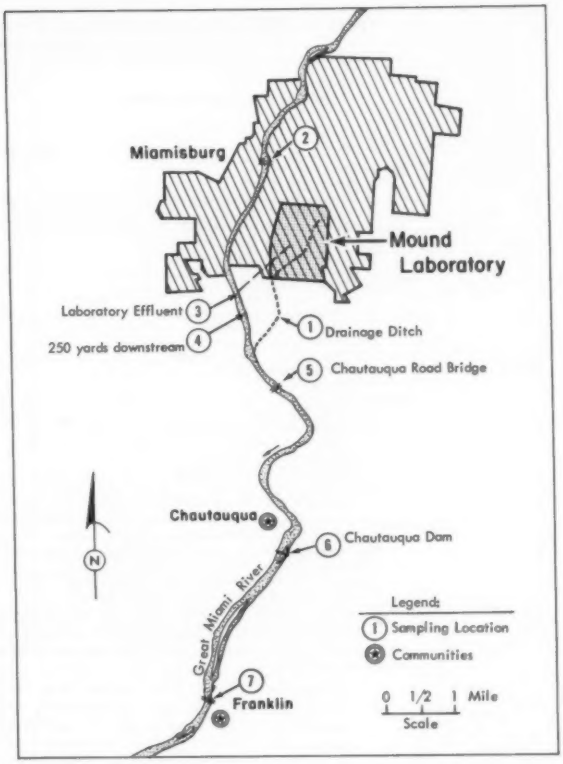

Figure 4. Water sampling locations, Mound Laboratory

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of hydrogen-3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 4) is the point of discharge of the liquid polonium waste to the Great Miami River, and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

All of the river samples are analyzed for polonium-210 and plutonium-238 and some of the samples are analyzed for tritium. The drainage ditch samples are analyzed for tritium and plutonium-238. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 9 on next page for January–June 1968.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	April 1968
July–December 1967	September 1968

Table 9. Offsite water monitoring for radioactivity, Mound Laboratory environs January–June 1968

Nuclide and sampling location [a]	Number of samples	Concentration (pCi/liter)	
		Maximum	Average [b]
Polonium-210 [c]			
1 (Drainage ditch)	24	21.62	4.01
2 (Upstream from laboratory)	24	1.80	1.80
3 (Laboratory effluent)	24	1,267.57	118.20
4 (250-yards downstream)	24	19.82	3.34
5 (Chautauqua Road Bridge)	24	5.40	2.02
6 (Chautauqua Dam)	24	1.80	1.80
7 (Franklin, Ohio)	24	1.80	1.80
Hydrogen-3 (tritium) [c]			
1 (Drainage ditch)	23	2.79×10^6	0.52×10^6
2 (Upstream from laboratory)	23	0.16×10^6	$.06 \times 10^6$
3 (Laboratory effluent)	23	1.13×10^6	$.27 \times 10^6$
4 (250-yards downstream)	23	$.19 \times 10^6$	$.06 \times 10^6$
5 (Chautauqua Road Bridge)	23	$.28 \times 10^6$	$.07 \times 10^6$
6 (Chautauqua Dam)	23	$.23 \times 10^6$	$.06 \times 10^6$
7 (Franklin, Ohio)	23	$.20 \times 10^6$	$.07 \times 10^6$
Plutonium-238 [c]			
1 (Drainage ditch)	24	2,454.16	481.14
2 (Upstream from laboratory)	24	15.42	5.95
3 (Laboratory effluent)	23	79.27	18.36
4 (250-yards downstream)	24	36.31	7.72
5 (Chautauqua Road Bridge)	24	10.84	5.75
6 (Chautauqua Dam)	24	8.48	5.10
7 (Franklin, Ohio	24	28.10	6.29

[a] See figure 4 for number of sampling locations.
[b] The applicable AEC radiation protection standards for uncontrolled area are as follows:
Polonium-210 in water: 7×10^2 pCi/liter.
Plutonium-238 in water: 5×10^1 pCi/liter.
Hydrogen-3 in water: 3×10^4 pCi/liter.
[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
Minimum detectable level for hydrogen-3 in water is 0.05×10^6 pCi/liter.
Minimum detectable level for plutonium-238 in water is 4.50 pCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

Reported Nuclear Detonations, April 1969

The U.S. Atomic Energy Commission announced that two nuclear tests of low-intermediate yield (20–200 kilotons TNT equivalent) were conducted underground on April 30, 1969 by the Atomic Energy Commission at its Nevada Test Site.

Shortly after the detonations, AEC instruments near ground zero of one of the tests showed some radiation readings slightly above background. It is not expected that any radioactivity will be detected offsite.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOLOGICAL HEALTH ASPECTS OF SPENT RADON SEEDS. *Richard F. Boggs, Gail D. Schmidt, and Kenneth D. Williams. Radiological Health Data and Reports, Vol. 10, May 1969*, pp. 185–190.

Following three incidents of radiation exposure to wearing jewelry contaminated with radioactivity were overexposed, the Bureau of Radiological Health (BRH) examined the early development, the present clinical use, and disposal of gold radon seeds, the suspected source of the contamination. The Ad Hoc committee called by the BRH to study the problem, recommended that (1) the State and local radiological health agencies that have regulatory authority over radon seeds be familiar with the appropriate regulations, (2) that users of radon be advised to keep an account of radon seeds procured, not to supply unused or spent radon seeds to any unauthorized person and to return all decayed or unwanted radon seeds to the supplier or persons authorized to receive such shipments, (3) gold refiners and processors be alerted to the possibility of receiving contaminated gold and efforts should be made to prevent such material from entering the commercial market, (4) the BRH consider the possibility of further investigation of the extent of the problem and consider providing technical assistance through appropriate agencies, and (5) the medical community be encouraged to investigate the feasibility of using other radionuclides for permanent implants.

KEYWORDS: Exposure, gold, lead–210, radon seeds, regulations.

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May 1969

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